APPENDIX B 2

APPENDIX B

B.10 – HYDRAULIC CONSIDERATIONS

Appendix D begins with a general examination of various hydraulic terminology, computer aides and considerations and then moves into specific requirements and analysis for several technical aspects of hydraulic determinations.

B.10.01 Definitions Retaliating to Hydraulics

BASE FLOOD: The flood having a 1% chance of being exceeded in any given year, or a 100-year flood.

BASE FLOOD PLAIN: The area subject to flooding by the 100-year flood.

DESIGN FLOOD: The peak discharge, volume (if appropriate), stage, or wave crest elevation of the flood associated with the probability of exceedance selected for the design of a highway encroachment. By definition, the highway will not be inundated by the design flood.

ENCROACHMENT: A highway and/or appurtenant feature within the limits of a flood plain. Encroachments may be transverse or longitudinal. A transverse encroachment is one that crosses the flood plain, such as a highway bridge project. A longitudinal encroachment is one that extends along the flood plain, such as a highway project along a river.

FEMA: Federal Emergency Management Agency

FHBM: Flood Hazard Boundary Map

FIRM: Flood Insurance Rate Map

FREEBOARD: The vertical clearance of the lowest structural superstructure above the water surface elevation of the overtopping flood.

NATURAL AND BENEFICIAL FLOOD PLAIN VALUES: Including (but are not limited to) fish, wildlife, plants, open space, natural beauty, scientific study, outdoor recreation, agriculture, aquaculture, forestry, natural moderation of floods, water quality maintenance, and groundwater discharge.

NFIP: National Flood Insurance Program

OVERTOPPING FLOOD: The flood described by the probability of exceedance and water surface elevation at which flow occurs over the highway, over the watershed divide, or through structures provided for emergency relief.

REGULATORY FLOODWAY: The flood plain area that is reserved in an open manner by federal, state, or local requirements, i.e., unconfined or unobstructed either horizontally or vertically, to provide for the discharge of the base flood so that the cumulative increase in water surface elevation is no more than a designed amount (not to exceed one foot as established by FEMA for administering the National Flood Insurance Program).

RISK: The consequence associated with the probability of flooding attributable to an encroachment. It shall include the potential for property loss and hazard to life during the service life of the highway.

RISK ANALYSIS: An economic comparison of a design alternative using expected total costs (construction costs plus risk costs) to determine the alternative with the least total expected cost to the public. It shall include probable flood-related costs during the service life of the facility for highway operation, maintenance, and repair for highway aggravated flood damage to other property and for additional or interrupted highway travel.

SCOUR REVIEW FLOOD: The overtopping flood or greatest flood drainage structures where overtopping is not practicable. The greatest flood used in the analysis is subject to a state-of-the-art capability to estimate the exceedance probability. This "greatest flood" shall be limited to a 500-year flood.

SIGNIFICANT ENCROACHMENT: A highway encroachment and any direct support of likely base flood plain development that would involve one or more of the following construction or flood-related impacts:

- A significant potential for interruption or termination of a transportation facility that is needed for emergency vehicles or provides a community's only evacuation route.
- A significant risk.
- A significant adverse impact on natural and beneficial flood plain values.

SUPPORT BASE FLOOD PLAIN DEVELOPMENT: To encourage, allow, serve, or otherwise facilitate additional base flood plain development. Direct support results from an encroachment, while indirect support results from an action out of the base flood plain.

B.10.02 PC Programs. The following hydraulic programs are available in Roadway Design for use by the districts:

- HEC-RAS (River Analysis System)

  Water surface program produced by the Corps of Engineers. This program should be used for all bridge and open channel hydraulics, bridge scour calculations, etc.

- HYDRAIN

  A compilation of several hydraulic programs produced by a joint effort of several states including Idaho. The following programs are included:

  - HYDRO

    A command line hydrology program that uses the rational, U.S. Geological Survey Regression, and log-Pearson Type III methods to determine the peak flow for a site. This program also develops >n IDF curve for any location in the United States.

  - NFF

    A compilation of statewide regression equations.

  - HYDRA

    A command line gravity pipe network hydraulics program that can be used either to analyse an existing storm drain/sanitary sewer system or design a new system.

  - HYCHL

    A command line as well as an intersection program that assists in the analysis and design of roadside channels and riprap lining.

  - WSPRO

    A command line step backwater program for natural channels with an orientation to bridge constrictions.

  - HY8

    An interactive and user-friendly program for design of highway culverts, design of energy dissipators, storm hydrograph generation, and reservoir routing upstream of a culvert.

B.10.03 Scour, Riprap, and Stream Stability. Scour, riprap, and stream stability are discussed in the following references:

- Drainage Design III, Open Channels, ITD
- Hydraulic Analysis for the Location and Design of Bridges, Highway Drainage Guidelines, AASHTO
- HRE Highways in the River Environment, FHWA
- HEC 11 Design of Riprap Revetment
- HEC 15 Design of Roadside Channels with Flexible Linings, FHWA

- HEC 18 Evaluating Scour at Bridges, FHWA
- HEC 20 Stream Stability at Highway Structures, FHWA
- HEC 23 Bridge Scour and Storm Instability Countermeasures

B.10.04 Hydraulic Concept Studies. Collect available data on runoff, discharges, flood plains, and alternative highway locations from:

- Alternative highway alignment maps.
- National Flood Insurance Program maps.
- Previous highway drainage studies.
- High-water marks.
- USGS, COE, etc., report.
- Location of water courses.
- Drainage areas.
- Present and future land uses.

Determine runoff and discharges for waterway crossings on each alternative highway alignment from (determine for normal design flood and for 100-year flood):

- Existing studies.
- Computations.

Determine 100-year flood plain from:

- Existing studies.
- National Flood Insurance Program maps.
- Computation of elevations and boundaries as necessary to assess risk.

B.10.05 Analysis of Highway Alternatives. Identify encroachments on all 100-year flood plains.

Identify impacts of alternative alignments on the 100-year flood plain:

- Environmental.
- Risk.
- Support flood plain development.
- If impacts are large, measures to minimize, restore, and preserve natural and beneficial flood plain values.

Identify National Flood Insurance Program status and constraints on flood plain encroachments (see following section).

Identify significant flood plain encroachments, as necessary. Determine size of drainage structure:

- A significant potential for interruption or termination of a transportation facility that is needed for emergency vehicles or provides a community's only evacuation route.
- A significant risk.
- A significant adverse impact on natural and beneficial flood plain values.

Evaluate alternative alignments to avoid longitudinal and significant encroachments in 100-year flood plains.

Coordinate studies with federal, state, and local water resource/environmental agencies.

Through public hearing notices, advise the public of significant encroachments under consideration.

Identify all 100-year flood plain encroachments in public hearings.

B.10.06 Draft Environmental Document. Review issues raised through public involvement procedures. For projects being processed as a categorical exclusion, document results of any concept studies, public involvement, etc., are required in the project records.

Present results of studies in draft environmental review document:

- Include an exhibit that displays both the alternatives and the approximate 100-year flood plain, as appropriate. Data from FEMA maps must be used, if available.
- Summarize the results of the concept hydraulic studies for each alternative.
- Indicate the consistency with existing or proposed regulatory floodways and the appropriate coordination (see the following section).
- Discuss the practicability of alternatives to significant encroachments.

B.10.07 Final Environmental Document. Review issues raised through public involvement procedures. Reevaluate the alternatives on the basis of the comments received and the water resources concerns, including potential support of any incompatible flood plain development.

After selection of the preferred location alternative for the final environmental document, review the alignment to see if any further efforts can be made to minimize encroachments or their impacts, considering input from the public and review agencies. Review the adequacy of hydrologic and hydraulic studies for assessment purposes, expanding them as necessary.

Prepare responses to the comments received. Meet with water resources agencies and the public, as necessary, to attempt to satisfy concerns.

Prepare a discussion of the flood plain impacts (including an "only practicable alternative finding," if appropriate, for significant encroachments).

Document the results of the preliminary hydraulic location studies and any commitments made in the environmental process. Make this information available to designers for use in further project development.

Make an "only practicable alternative finding" available to regional planning agencies.

B.10.08 Design Studies.

Obtain the alignment and profile of the selected alternative.

Review commitments made in environmental documents and document constraints.

Review National Flood Insurance Program maps and flood plain zoning.

Prepare the hydrologic analyses for the project and for specific appropriate sites:

- List the available flood-frequency records, flood studies, etc.
- Evaluate the potential for changes in watershed characteristics that would change magnitude of flood peaks, e.g., urbanization, channelization, etc.
- Plot the flood-frequency curve.
- Determine the distribution of flood and velocities for several discharges or stages in the natural channel for existing conditions.
- Plot the stage-discharge-frequency curve.

  Determine the need for a site map, which is used for estimating flood flow distribution, selecting cross sections of a stream, showing locations of the proposed encroachment and structure(s), and indicating the existing features (stream controls, encroachments, development and highway structures, etc.).

- Specially prepared map showing contours, vegetation, and improvements.

- In some cases, cross sections normal to flood flow are acceptable in lieu of a map. Determine the number of sections necessary.

  Use survey data to select encroachments to review in the field and initiate a survey data report that includes the following:

- Photographs (showing existing structures, past floods, main channel, and flood plain) to document existing conditions and to use in assigning resistance values.
- Comments on drift, ice, nature of streambed, bank stability, bend meanders, vegetation cover, and land use.
- Factors affecting water stages, such as high water from other streams, reservoirs (existing or proposed and approximate date of construction), flood control projects (give status), and other controls.
- Locations and elevations of high-water marks along stream, giving dates of occurrence.
- The relative importance and/or value of the adjacent property and, where appropriate, a list of facilities susceptible to flooding and first-flood elevations.
- Features that are constraints to modifying the upstream water surface elevation.
- The evaluation of the need for riprap and/or scour protection, including the need for spur dikes, energy dissipaters, countermeasures, etc.
- The location of existing structures (including relief or overflow structures) with respect to the proposed crossing or encroachment (upstream, downstream, as well as the existing roadway) and describe each fully, giving the:
  - Type, including span lengths and number of spans, bent design, pier orientation, culvert size, and number of cells.
  - Foundation type (spread footing, piling. etc.) and depth.
  - Scour history at abutments, bents, culvert outlets; headcutting; and stream aggradation and degradation.
  - Cross section beneath structures, noting clearance to superstructure and skew with direction of the current during extreme floods (add to the survey party instructions).
  - Flood history, high-water marks (dates and elevation), nature of flooding (including overtopping), damages, and sources of information.
  - Damage from abrasion, corrosion, wingwall failure, and culvert end failure.
- Site map preparation.

A field review should be performed by the designer to review all the locations that will require drainage structures.

B.10.09 Hydraulic Analyses. For each encroachment, determine the appropriate method for studying the design alternatives: mathematical model, physical model, or both.

Rate the capacity of the existing features and, if necessary, adjust the stage-discharge-frequency relationship.

Prepare the design of the bridge waterways:

- Identify the features that are constraints to modifying the upstream water surface elevation:
  - Land use.
  - Development.
  - Watershed divides.

- Flood plain values, e.g., wetlands, etc.

- Determine the navigation requirements and evaluate the need for channel modifications and controls.
- Compute the backwater for various bridge lengths, approach profiles, and discharges:
  - Review the flow distribution and consider the need for auxiliary structures.
  - Plot the data as a family of curves on the stage-discharge-frequency curve developed for the existing conditions.
- Design the encroachments using minimum criteria and evaluate and document the risks.
- Calculate the contraction scour and scour depth at piers. Attach copy of HEC-RAS scour analysis report.
- **Do not** calculate bridge abutment scour. Calculate appropriate riprap size, blanket thickness for detail to protect bridge abutments, and attach to the Hydraulic Report.
- Design the embankment, bank, and channel protection and scour attenuation devices, if required. Investigate the need for the design spur dikes.

Prepare the design culverts:

- Identify the features that are constraints on headwater elevation and highway profile.
- Evaluate the abrasion and corrosion potential (see Section 300):
  - Eliminate from consideration the materials that will give unsatisfactory service life.
  - Choose the protective measures.
- Compute and plot the performance curves for trial culvert sizes.
- Evaluate the need and provisions for fish passage.
- Select the culvert design (see the Risk Analysis/Assessment section):
  - Design encroachments using minimum criteria.
  - Evaluate and document risks.
- Determine the hydraulically equivalent sizes for bid alternatives.
- Evaluate the need and design for debris control.
- Evaluate the need and design for outlet protection.
- Investigate the need and design for protection against failure by buoyancy and/or by separation at joints.

Prepare the design of longitudinal encroachments. Determine the navigation requirements and evaluate the need for channel modifications and controls:

- Determine the effect of the proposed encroachment on water-surface profiles using various roadway profile alternatives.
- Design the encroachments using minimum criteria and evaluate and document the risks.
- Evaluate the effects on scour and deposition in channel and tributaries.
- Design the embankment, bank, and channel protection.

B.10.10 Documentation. Show the final layout of encroachments in the plan and profile, including the magnitude, elevation, and exceedance probability of the scour review flood and the base flood, if appropriate (the overtopping flood for interstate mainlines shall not be less than the 50-year flood).

Complete project files should include:

- Hydrologic and hydraulic data and design computations.
- As appropriate, information on:
  - The need for emergency supply and evaluation routes.
  - Hydraulic controls that affect the proposed drainage structure.
  - Constraints imposed by requirements for highway geometrics.
  - Navigation requirements.
  - Channel modification.
  - Effects on stream stability.
  - Effects on stream ecology.
  - The need for stream controls to protect highway.
  - The need and provisions for fish passage.
  - Consistency with the National Flood Insurance Program.

See Figure B-1 for the hydraulics report outline.

Figure B-1

HYDRAULICS REPORT OUTLINE

A. Existing Structure

1. Vicinity sketch
2. Problems and adverse conditions
   a. Scour
3. Stream stability
4. Photos - Aerial (if available) and ground
5. Hydrology
   a. Floods
      (1) Design - 50-year
      (2) Flood insurance consistency - 100-year
      (3) Scour design - 100-year
      (4) Scour review - Lesser of overtopping or 500-year
   b. Methods
      (1) Gage data - 20 years of records or more, including a log-Pearson printout
      (2) Four U.S. Geological Survey methods, including data
6. Hydraulics

B. Proposed Structure

1. Hydraulics - Include calculations or computer printout
2. Problems and adverse conditions - Solutions
3. Information (as appropriate) on:
   a. Hydraulic controls that affect the proposed structure
   b. Channel modification
   c. Effects on stream stability
   d. Need and provisions for fish passage
   e. Navigation requirements
   f. Need for stream controls to protect highway
      (1) Such as guide banks or trash racks
   g. Constraints imposed by highway geometrics
   h. Effects on stream ecology
   i. Need for emergency supply and evacuation routes

C. Evaluate Scour Data and Need for Riprap at Piers and Abutments

1. Show typical section, size and toe detail
2. Show placement

D. Site Map With Contours

E. Cross Sections

F. Permit Status and Consistency With Flood Insurance Requirements

G. *ITD-210*, *Hydraulic Structures Survey*

B.10.11 Deck Drainage. Slotted drains and embankment protectors can be used to intercept runoff at each end of a bridge. The length of the slotted drain or embankment protector can be determined from Figure 7-2 in Section 600.

The slotted drain or embankment protector lengths for super elevated roadways not covered in this table can be determined from the following equation:

$L_T = 0.6\ Q^{0.42} S^{0.3} (1/nSx)^{0.6}$

Where

L_T	=	Length of slotted inlet required to intercept 100% of the gutter flow in feet
Q	=	Discharge in cfs
n	=	Mannings n value of pavement (typically 0.016)
Sx	=	Cross slope of pavement in feet per foot

Slotted drains should terminate in a standard catch basin with a facility for removing sand (Standard Drawing D-1-B).

References: Urban Drainage Design Manual, HEC-22 FHWA-SA-96-078

Design of Bridge Deck Drainage, HEC-21 FHWA-SA-92-010

B.10.12 Culvert Design Guide. Establish drainage areas along the route-proposed alignment.

Determine the area by Planimeter, grid intersect, or other acceptable method.

Compute the design discharge:

- Watershed area >10 mi^2.
  - Check for gage data - log-Pearson Type III
  - U.S. Geological Survey reports,

    U.S. Geological Survey Water Resource Investigations 02-4170
    U.S. Geological Survey open file report #81-909, pp. 21-30
    U.S. Geological Survey open file report #93-419
    U.S. Geological Survey Water Resources Investigations 7-73
    U.S. Geological Survey Water Resources Investigations 80-32, pp. 33-36
- Watershed area <10 mi^2 - small area nomograph.
- Rational method can be used on culverts for watersheds up to 200 acres (81 ha.)
- NRCS TR-55 Method
- USGS 93-419, "Methods for Estimating Magnitude and Frequency of Floods in the Southwestern United States" (Arid Study)

Locate a possible culvert cross drain station and check FEMA for a possible flood insurance zone or regulatory floodway.

For the small area nomograph, i.e., <26 km^2, determine:

- The elevation drop in the drainage (H).
- The length of drainage (L).
- The area of drainage (A).
- The design storm area classification.
- The runoff factor (K_t) for a thunderstorm, which requires time and Kb.

  Needed for Kb

(1) ground cover

(2) avg. side slopes

(3) exposure of watershed such as NE, West or South

- The snowmelt zone and the K_t for snowmelt.

Complete the small area nomograph for Q (pick the larger of the Qs for design) derived from:

- Thunderstorm
- Snowmelt

Establish the stage discharge diagram for tailwater from the cross section of stream and slope. Use the HY-8 of Hydrain, the Mannings Equation, or nomographs.

Determine the length of the slope and allowable headwater depth from the field data.

Determine the headwater from HY-8 or nomographs. Repeat the process for various sizes. Refer to FHWA HDS-5 for nomographs of various shapes.

Establish the stage discharge curve for the culvert, if necessary.

Check the minimum freeboard and determine the outlet velocity from H-P programs or Mannings formula.

Determine the need for outlet protection, FHWA, HY-8 Culvert Design Program, HEC-11 (pp. 11-6), HEC 14, and previous experience.

Determine the height and type of fill material, culvert material, required gage, if applicable, and other pertinent data.

Check for the existing culvert at the same station or near the station.

Talk with landowners and maintenance crews for problems, flooding, and over-the-ramp floods.

List the final determination on the Pipe Culvert Summary.

B.10.13 Head Determinations.

Allowable Headwater

The allowable headwater is the difference in elevation above the inlet invert that water is allowed to rise in order to allow a given amount of water to flow through a culvert.

Drift and Ice

Trash racks can be installed in the event of unusual drift problems. However, they require periodic maintenance and should only be used where necessary. Highway Engineering Circular No. 9, *Debris Control Structures*, by the FHWA contains several designs for trash racks.

Minimum Freeboard

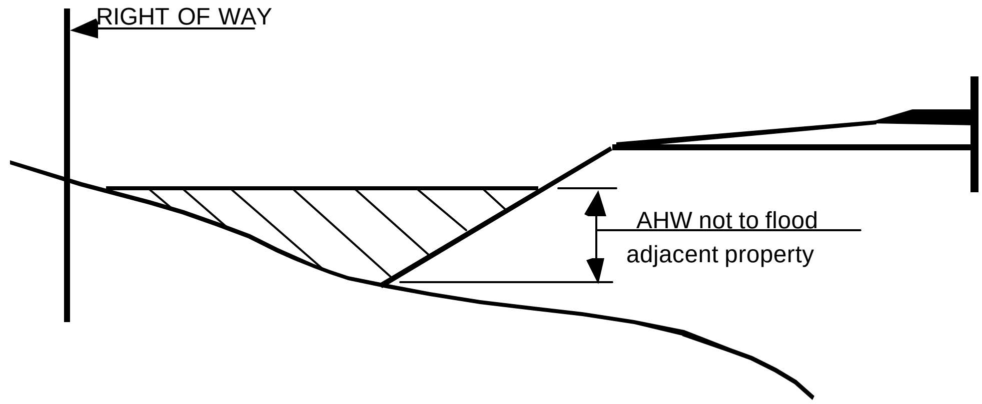
The allowable headwater (AHW) should not exceed the total head minus a freeboard of two feet to the bottom of the subgrade elevation. **(Subgrade elevation is interpreted to be the bottom of the aggregate base course)** However, if the top of the pipe is less than 2.0’ (610 mm) below subgrade, then the allowable headwater shall not exceed the pipe diameter.

Embankment Material - Entrance Erosion

Depending on the embankment material used, headwater at pipe entrances can cause erosion. Additional head may reduce cost of installation if a smaller pipe diameter can be used. This savings is lost, however, if expensive erosion protection at the entrance must be provided. A brief economic analysis will give the desired solution.

Backwater on Adjacent Property

The allowable headwater shall not cause backwater of the design storm to accumulate beyond the right-of-way.



Where additional headwater would result in savings of pipe diameter, the price of purchasing additional right-of-way should be compared to the possible savings of installation costs.

In cases where adjacent properties consist of low value land, the extra right-of-way cost may well be less than larger pipe sizes.

B.20 – FLOOD PLAIN ENCROACHMENT

B.20.01 National Flood Insurance Program Constraints on Flood Plains. The National Flood Insurance Program (NFIP) was initiated to reduce future and recurring damages due to flooding. Every community located in a flood hazard area has the opportunity to participate in the program. The program makes subsidized flood insurance available to property owners at reasonable rates. A condition of participation is that each community must pass and enforce ordinances to control development in 100-year flood plains.

Every highway encroachment in an NFIP-identified 100-year flood plain must be located and designed to be consistent with ordinances that are passed to qualify a community for the NFIP. If this is not done, the affected community's participation in the program (subsidized insurance) is jeopardized.

A Floodplain Development Permit must be obtained from the community (city or county) for any encroachment in a 100-year floodplain. The floodplain development permit should accompany the ITD-210, Hydraulic Report submittal. If the community does not use a formal permit form, a letter from the community's Floodplain Ordinance Administrator approving the encroachment is acceptable. If the district is forwarding a consultant design, make sure the consultant has obtained the permit or letter before forwarding to Roadway Design.

If the encroachment is in the regulatory floodway, the new structure or replacement structure cannot increase the water surface elevation unless a Letter of Map Revision (LOMR) is processed through the Federal Emergency Management Agency (FEMA). A computer analysis may or may not be needed to verify this. Check with Hydraulics Engineer if a regulatory floodway is involved. Each community has a set of Flood Insurance Rate Maps (FIRM), Floodway Maps and Flood Insurance Studies (FIS) for use in making these determinations.

Any proposed encroachment in a 100-year flood plain must be evaluated to determine the NFIP status of the area and the constraints on encroachments. The following items are the various situations with corresponding constraints that will occur in a community participating in the NFIP. (Replacement of an existing bridge will be consistent with the NFIP if the waterway under the new bridge is equal to or greater than that of the existing bridge and no additional encroachment in the regulatory floodway is involved.)

1. A "Regulatory Floodway" Has Been Established (see FEMA maps, which are available from the Idaho Department of Water Resources)

    a. An encroachment is consistent with the regulatory floodway if the regulatory floodway is spanned in both vertical and horizontal dimensions – that is, there are no encroachments into the regulatory floodway.

    b. An encroachment can be consistent with the regulatory floodway if the only regulatory floodway encroachment is by bridge piers. Hydraulic calculations may show that the piers have no discernible effect and, if so, no compensation would be required. Channel or other improvements at the structure may be necessary to compensate for the pier encroachment.

    c. An encroachment can be made consistent with the "regulatory floodway" by revising the regulatory floodway. Many regulatory floodways and flood plains were delineated without sufficient detail to accurately define their boundaries. Therefore, it may be prudent and cost effective to revise the floodway rather than meet the requirement of 1.a. or 1.b. A regulatory floodway may be revised by moving it horizontally. However, the following criteria will apply:

        (1) Backwater cannot be increased – that is, the elevation of the top of the regulatory floodway (the water surface profile published in the flood insurance study) cannot be raised above the 1.0 foot maximum.

        (2) The community and FEMA must agree to revision of the regulatory floodway.

d. When it is "demonstrably inappropriate" to design an encroachment to fit under 1.a., 1.b., or 1.c., an alternative regulatory floodway with increased backwater may be approved. However, this option should be considered only as a last resort.

e. For any of the above situations, encroachments in the flood fringe area are consistent with the NFIP. However, buildings constructed in the 100-year flood plain must be flood-proofed so the 100-year flood will not damage them.

2. A "Regulatory Floodway" Has Not Been Established (see FEMA maps)

a. In a flood plain shown on a Flood Insurance Rate Map (FIRM), where no regulatory floodway has been designated, highway encroachments should be designed to allow no more than a 1-foot (300 mm) increase in the base flood elevation based on technical data.

b. In a flood plain shown on a Flood Hazard Boundary Map, where no regulatory floodway has been designated, highway encroachments should be designed to allow no more than a 1-foot (300 mm) increase in the base flood elevation based on technical data.

c. In a flood plain shown on a FIRM, where no regulatory floodway has been designated, highway encroachments causing less than 1 foot (.3 meter) of backwater for the delineated 100-year flood surface are acceptable.

3. Encroachment of Highway on Floodway

Where it is not cost effective to design a highway crossing to avoid encroachment on an established floodway, a second alternative would be a modification of the floodway itself. Often, the community will be willing to accept an alternative floodway configuration to accommodate a proposed crossing provided NFIP limitations on increases in the base flood elevation are not exceeded. This approach is useful where the highway crossing does not cause more than 1 foot rise in the base flood elevation. In some cases, it may be possible to enlarge the floodway or otherwise increase conveyance in the floodway above and below the crossing in order to allow greater encroachment. Such planning is best accomplished when the floodway is first established. However, where the community is willing to amend an established floodway to support this option, the floodway may be revised.

The responsibility for demonstrating that an alternative floodway configuration meets NFIP requirements rests with the community. However, this responsibility may be borne by the agency proposing to construct the highway crossing. Floodway revisions must be based on the hydraulic model that was used to develop the currently effective floodway but updated to reflect existing encroachment conditions. This will allow determination of the increase in the base flood elevation that has been caused by encroachments since the original floodway was established.

Alternate floodway configuration may then be analyzed. Base flood elevation increases are referenced to the profile obtained for existing conditions when the floodway was first established.

Data submitted to FEMA in support of a floodway revision request should include the following:

a. Copy of the current regulatory Flood Boundary Floodway Map showing existing conditions, proposed highway crossing, and revised floodway limits.

b. Copy of computer printouts (input, computation, and output) for the current 100-year model and current 100-year floodway model.

c. Copy of computer printouts (input, computation, and output) for the revised 100-year floodway model. Any fill or development that has occurred in the existing flood fringe area must be incorporated into the revised 100-year floodway model.

d. Copy of the engineering certification is required for work performed by private subcontractors.

The revised and current computer data required above should extend far enough upstream and downstream of the floodway revision area in order to tie back into the original floodway and profiles using sound hydraulic engineering practices. This distance will vary depending on the magnitude of the requested floodway and the hydraulic characteristics of the stream.

A floodway revision will not be acceptable if development that has occurred in the existing flood fringe area since the adoption of the community's floodway ordinance will now be located within the revised floodway area unless adversely affected adjacent property owners are compensated for the loss.

If the input data representing the original hydraulic model are unavailable, an approximation should be developed. A new model should be made using the original cross section topographic information, where possible, and the discharges contained in the Flood Insurance Study that establish the original floodway. The model should then be run confining the effective flow area to the currently established floodway and calibrated to reproduce, within 0.10 foot (30 mm), the "With Floodway" elevations provided in the Floodway Data Table for the current floodway. Floodway revisions may then be evaluated using the procedures outlined above.

4. Floodway Encroachment Where Demonstrably Appropriate

When it would be demonstrably inappropriate to design a highway crossing to avoid encroachment on the floodway and where the floodway cannot be modified such that the structure could be excluded, FEMA will approve an alternate floodway with backwater in excess of the one foot maximum only when the following conditions have been met:

a. A concept study has been performed and FHWA finds the encroachment is the only practicable alternative.

b. The constructing agency has made appropriate arrangements with the affected property owners and the community to obtain flood easements or otherwise compensate them for future flood losses due to the effects of the structure.

c. The constructing agency has made appropriate arrangements to ensure that the National Flood Insurance Program and Flood Insurance Fund do not incur any liability for additional future flood losses to existing structures that are insured under the program and grandfathered in under the risk status existing prior to the construction of the structure.

d. Prior to initiating construction, the constructing agency provides FEMA with revised flood profiles, floodway and flood plain mapping, and background technical data necessary for FEMA to issue revised Flood Insurance Rate Maps and Flood Boundary and Floodway Maps for the affected area upon completion of the structure.

5. Flood Plain Encroachment

ITD-2792, *Summary of Flood Plain Encroachment*, is a format that may be used to summarize the results of a flood plain encroachment study. *ITD-2665*, *Floodway Revision Requirement*, should be used when it is necessary to revise a regulatory floodway.

6. Temporary Construction

Temporary construction, such as forms, coffer dams, retaining walls, etc., within a Regulatory Floodway must be approved by the local government. The rise in water surface elevation must be limited to 0.2 to 0.3 foot (61 to 91 mm). The construction should be scheduled so all restrictions will be removed by November 1, if possible.

Temporary crossings are considered as temporary construction and can only be left in for 12 months. The floodway must be revised according to FEMA regulations if the crossing is left in more than 12 months (see Figure B-2).

Figure B-2

U.S. Department of Transportation
Federal Highway Administration

Memorandum

Room 312 Mohawk Building
708 S.W. Third Avenue
Portland, Oregon 97204

Subject: Temporary Construction In Floodways

Date: August 10, 1989

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FHWA - IDAHO DIVISION
AUG 14 1989

	DIV ADMIN	✓	AREA ENGR 1
	EA SEC	✓	AREA ENGR 2
✓	ASST DIV AD	✓	AREA ENGR 3
✓	HEAD OPS	✓	ASST BR ENG
	PLANNER		DIC
	ROW OFF		SI 1
	FIN MGR		SI 2
	FIN SP		SI 3
	FISCAL CLK		DWCS SEC
	FILE		

From: J. P. Clark
Deputy Regional Administrator

Reply to Attn of: HST-010.3
File: 530.5

To: DIVISION ADMINISTRATORS
Mr. R. E. Ruby, Juneau, Alaska (HBR-AK)
Mr. J. T. Coe, Boise, Idaho (HFO-ID)
Mr. D. E. Wilken, Salem, Oregon (HBR-OR)
Mr. B. F. Morehead, Olympia, Washington (HBR-WA)

and Mr. J. N. Hall, Division Engineer
Western Federal Lands Highway Division (HDF-17.221)
Vancouver, Washington

Due to a recent inquiry from the Idaho Division, we requested that FEMA provide us with some guidance regarding temporary construction practices and also temporary crossings in regulatory floodways. Attached is their regional response which was also sent to their Headquarters Office for confirmation.

To summarize, strict interpretations of FEMA's regulations makes no allowances for temporary structures. They are handled the same as permanent structures, i.e., if cofferdams or falsework, etc., creates more than the allowable amount of backwater, floodway and ensuing map revisions are required. However, FEMA does provide some latitude when temporary construction or structures are considered. They feel that the only reasonable course of action is to have the local government permit the final structure design regardless of the shape or timing of the temporary construction practice. Otherwise, there would be lengthy delays while map revisions were made for the temporary structures and then again when the falsework, etc., was removed and the final structure was in place. It is this offices opinion that the FEMA policy is reasonable and prudent.

Additionally, we concur with FEMA's recommendations that preliminary calculations should be made by the constructing agency to assure that the backwater effects created by the temporary structure or construction ~~is~~ are within tolerable limits; a 0.2' or 0.3' rise. Also, if at all possible, construction practices should occur during low flow months; June 1 through October 31. Finally, it is FEMA's opinion that any increased flooding caused by temporary construction is the responsibility of constructing agency. Therefore, it is recommended that the policies stated in their August 3, 1989 letter be strictly followed.

If further guidance is provided by FEMA's Headquarters office, I will be sure to forward it on to you. Also, if you have any comments or questions, please call.

Christopher N. Dunn
Christopher N. Dunn, P.E.
Hydraulic Engineer

Attachment

B.30 – TECHNICAL DATA

B.30.01 Hydrology.

> If calculations are for a metric project, final Q values obtained from hydrology calculations, U.S. Geological Survey regression equations, nomographs, charts, etc., should be converted from cubic feet per second to cubic meters per second.

B.30.02 Small Areas Nomograph. Tables and nomographs of Figures A-3 and A-5 and the following information can be used to determine the design discharge for small areas.

The nomograph gives maximum discharge for both snowmelt and thunderstorm runoff. Runoff is figured for both cases and the higher discharge is used.

B.30.03 Thunderstorm Runoff. The following information must be obtained (the first three factors can be determined from aerial photos and contour maps, the fourth factor can be determined from the map on the nomograph, and the fifth factor can be determined from Figure B-4):

1. Elevation drop in the drainage (H).
2. Length of the drainage (L).
3. Area of the drainage (A).
4. Design storm area classification (Area I, II, or III).
5. Runoff factor (K_t).

B.30.04 Snowmelt Runoff. The following information must be obtained:

1. Snowmelt zone (Zone A, B or C).
2. Area of drainage (A).
3. Runoff factor (K_t).

The snowmelt zone is determined from Figure B-5, the area of drainage is determined from aerial photos and contour maps, and the runoff factor is determined from the following information:

1. Runoff factors (snowmelt).
2. Assume the basic runoff factor for snowmelt to be 55 percent.

Figure B-3

RUNOFF FACTORS

FINAL Q VALUES FROM NOMOGRAPH WILL BE CONVERTED FROM CU. FT./SECOND TO CU. METERS/SECOND

TABLE FOR RUNOFF VALUES - K_b

		Average side slopes				
		0%	25%	50%	75%	100%
Vegetative	200%	5	10	20	30	40
Ground	150%	10	20	30	40	50
Cover	100%	17	30	40	50	60
	50%	22	35	50	60	70
	10%	27	39	52	62	78
	0%	30	40	55	67	80

"Vegetative ground cover" = $\frac{\text{Area of leaves, needles}}{\text{Area of ground}}$

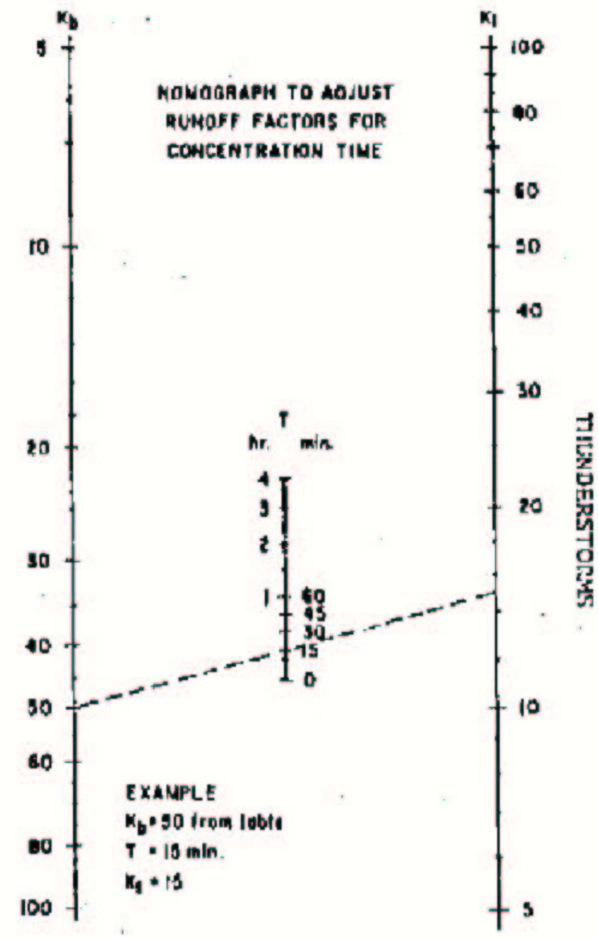
Ex:	
Closed stand of timber	200%
Pasture land	75-150%
Cheat Grass	15-50%
Sagebrush	20-60%
Wheat field	0-50%

Modification for infiltration: .

Granular - Chohesionless soils	0.5 - 0.7
Silt, loam	0.9 - 1.1
"Heavy" soils, clay	1.3 - 1.5

Example: Ground cover is cheat grass, with average side slopes of 50% and the soil type is loam 50% vegetative ground cover and 50% side slope gives a K_b of 50 from the table. Modification for infiltration 1 (for loam). K_b is equal to 50.

Example: (Thunderstorm) See figures 456-03



A culvert site in Area I is 4,500 ft. downstream and 700 ft. lower than the most remote point on the watershed. The tributary basin has an area of 500 acres, and the average ratio of runoff to precipitation (Kt) is found to be 15% as shown on Nomograph. The line passes through H = 700 ft., L = 4,500 ft., I = 1.9., A = 500 ac., P = 1000., Xt = 15 and results in Q = 140 Cu. Ft./Second.

Figure B-4

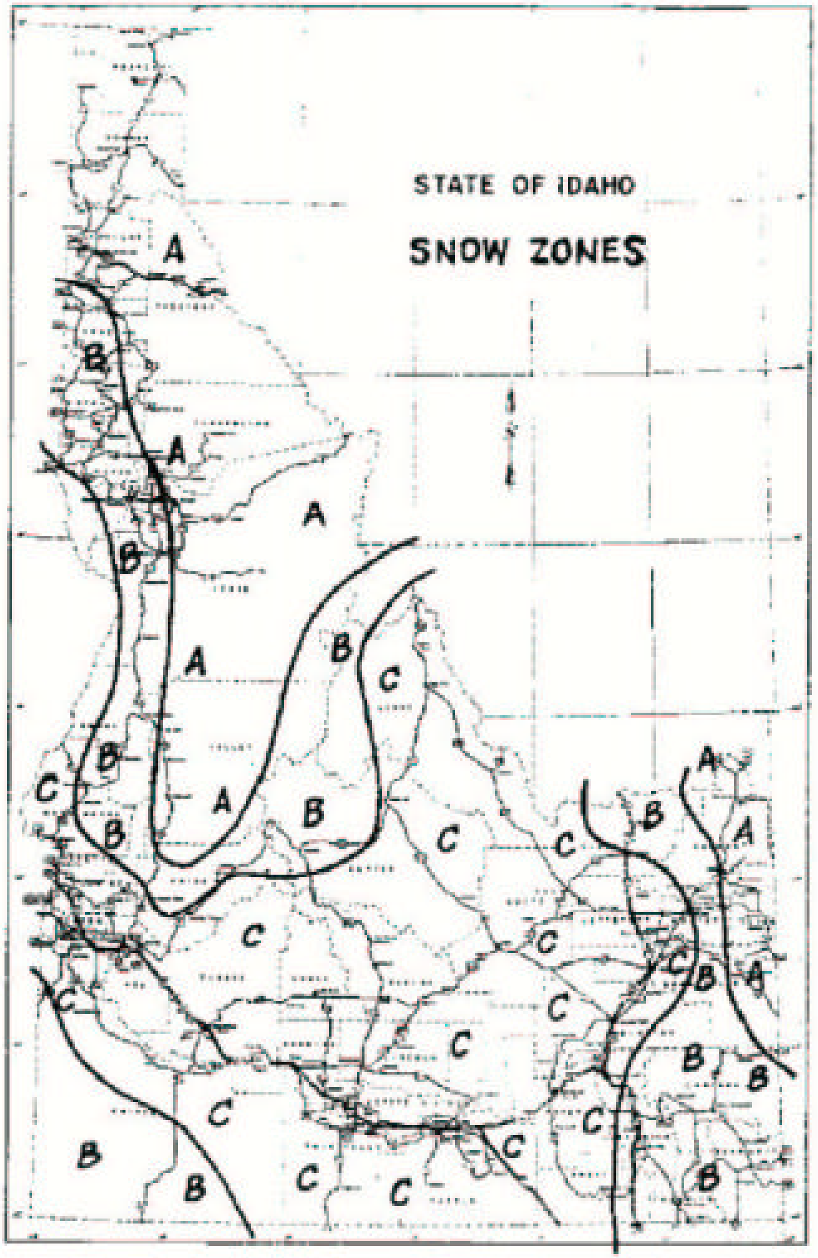
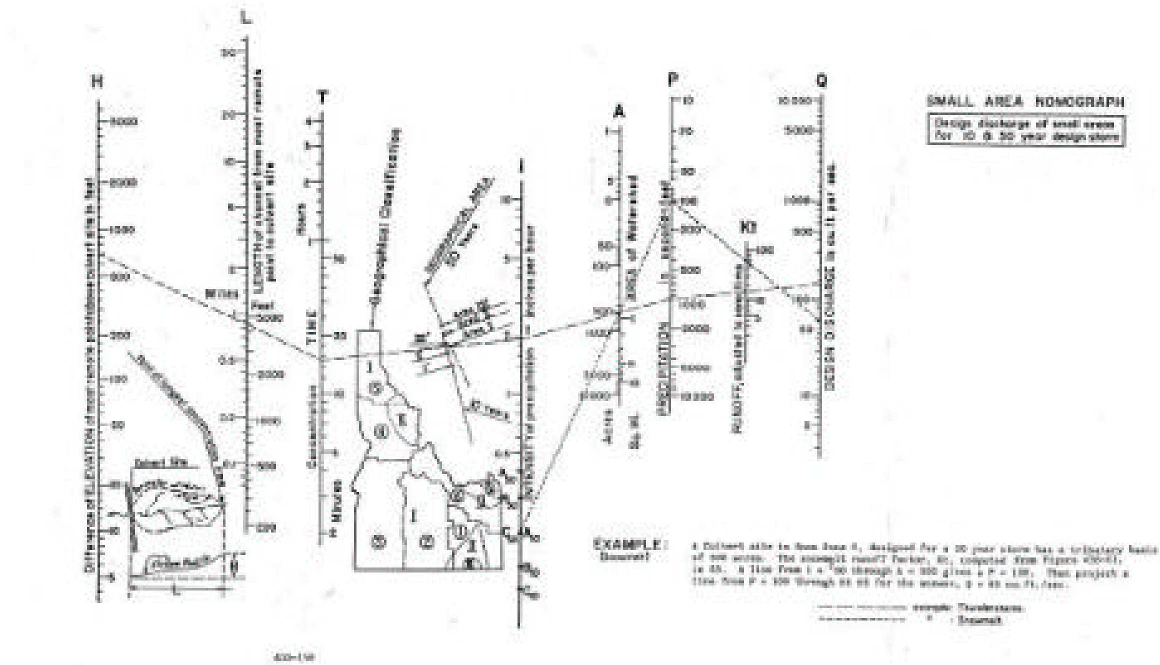

STATE OF IDAHO
SNOW ZONES
A
B
A
A
B
A
B
C
C
B
A
B
C
C
B
A
A
C
C
C
B
A
C
C
B
B
C
C
B
C
C
C
B

Figure B-5


SMALL AREA NOMOGRAPH
Design discharge of small areas for 10 & 50 year design storm
EXAMPLE:

B.30.05 Discharge Determination.

Step One: Determine:

- Exposure of watershed, e.g., NE.
- Vegetative ground cover of watershed (see Figure B-3).
- Area of watershed.

Step Two: Add to the basic runoff factor the following amounts, depending on average exposure, as follows:

- N 0%
- NE, NW 2%
- E, W 4%
- SE, SW 6%
- S 8%

Step Three: Add the following amounts depending on vegetative ground cover, as follows:

- 200% 0%
- 150% 4%
- 50% 8%
- 0% 12%

Use weighed averages if distribution is uneven.

Step Four: Add the following amounts depending on the area of the watershed, as follows:

- 0 - 2 square miles 10
- 2 - 5 square miles 6
- 5 - 8 square miles 3
- over 8 square miles 0

Example: A NW exposed watershed with average vegetative ground cover of 120 percent contains 6.5 square miles.

Runoff factor (K_t) is 55 + 2 + 5 + 3 = 65

B.30.06 Snowmelt Zones. Very little is known of the rate of snowmelt throughout Idaho. Before snow can melt, heat has to be transferred from the atmosphere or the soil into the snow layers. The laws governing this heat exchange are rather complex. Snow melts rapidly when air temperatures and wind velocities are high.

Idaho has been divided into three different snowmelt zones. Again, this information is used when computing snowmelt runoff by the "Small Area Nomograph" method. Figure B-4 shows the location of these three snowmelt zones.

B.30.07 Flood Type Zones. Major streams in Idaho have their peak discharge in winter or spring. These high discharges are caused by snowmelt or a combination of rain and snowmelt. When analyzed, the cause of high discharges for small watersheds, particularly in southern Idaho, have their maximum runoff in summer as a result of convective storms.

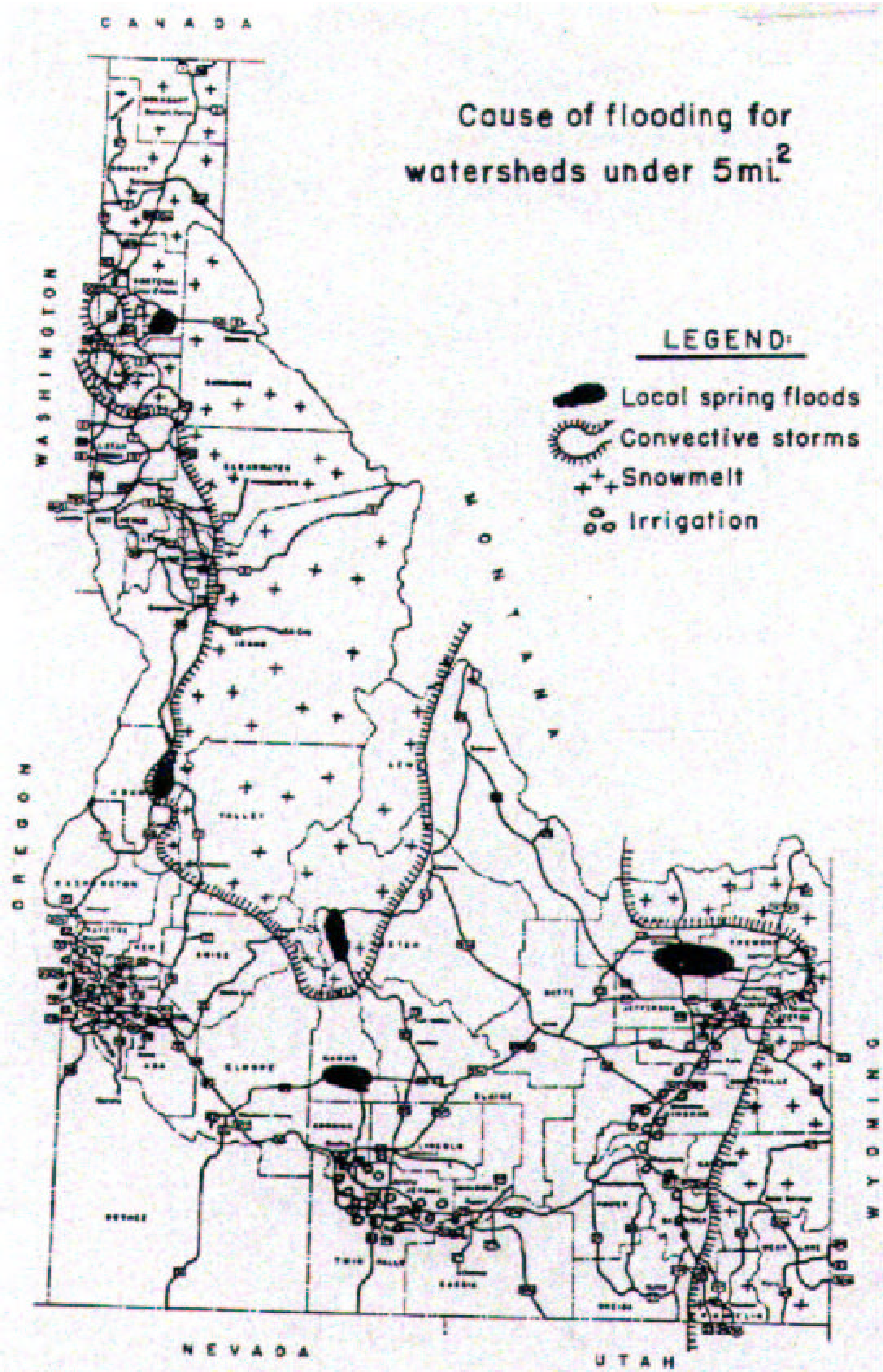
In some isolated areas, drainage problems exist not so much because of the high discharges but because the terrain is so flat that water simply cannot get away fast enough.

Finally, in other areas of Idaho, drainage problems are directly related to the flow of irrigation and irrigation-drainage water. Figure B-6 shows various causes for floods in small watersheds. This map does not show all the details, but the designer can use it to determine the principal causes of floods in the immediate area of a project.

B.30.08 Basic Data. Based on U.S. Weather Bureau records, Idaho has been divided into different intensity-duration-frequency (IDF) zones. The map in Figure B-7 shows the different areas. The graphs (nine pages) in Figure B-8 give IDF information for each zone.

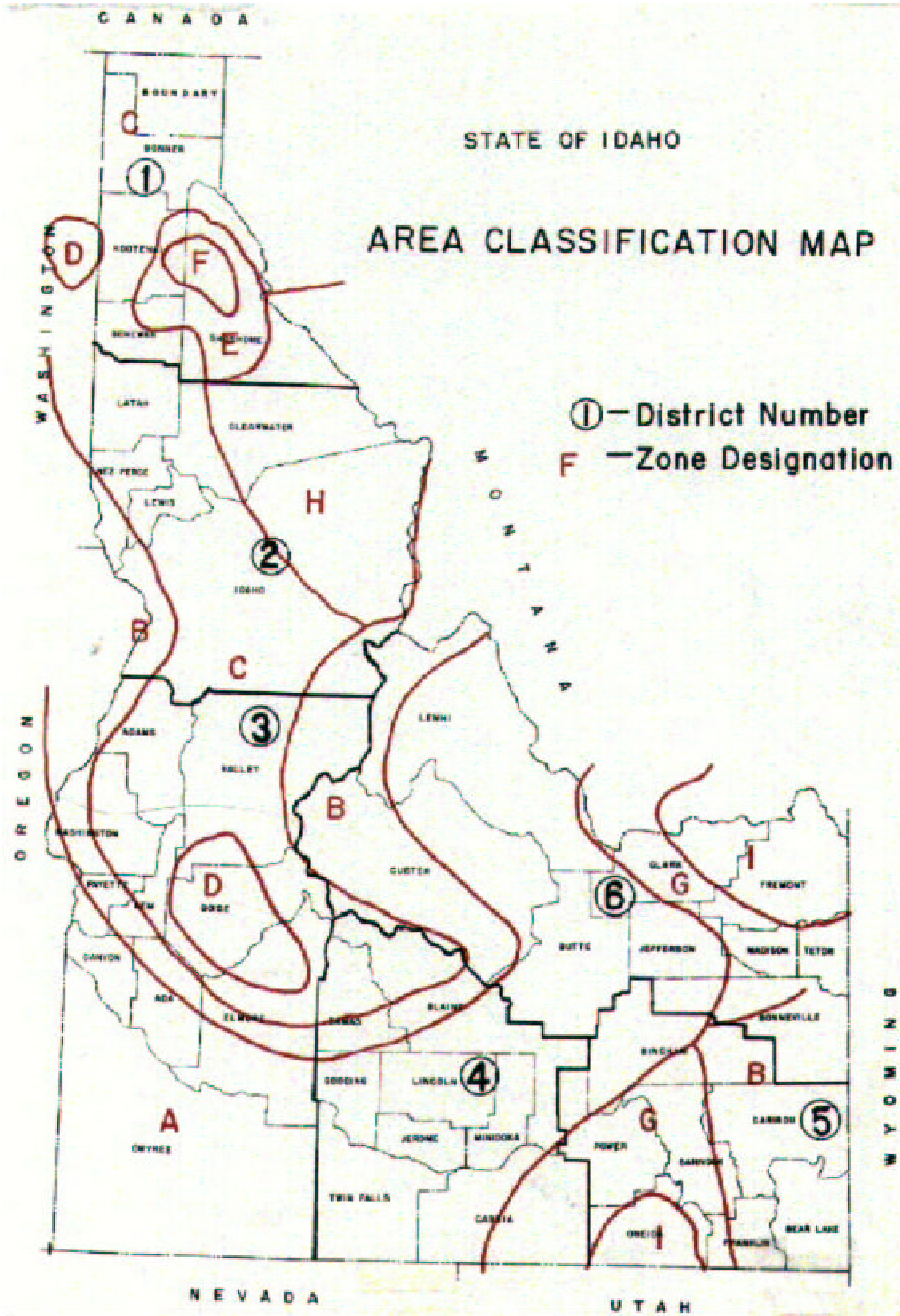
When using these graphs, it must be kept in mind that the data from which they are drawn are sporadic and much more information is needed for short-duration storms in order to arrive at more definitive answers. These graphs provide various rainfall intensities depending upon the length of the storm and the return period.

IDF curves were used as a basis for the Small Area Nomograph (Figure B-5) for runoff based on precipitation.



CANADA
Cause of flooding for watersheds under 5mi.²
LEGEND:
Local spring floods
Convective storms
Snowmelt
Irrigation
WASHINGTON
OREGON
MONTANA
WYOMING
NEVADA
UTAH

Figure B-7



CANADA
STATE OF IDAHO
AREA CLASSIFICATION MAP
① — District Number
F — Zone Designation
WASHINGTON
OREGON
MONTANA
WYOMING
NEVADA
UTAH
BOUNDARY
BONNER
KOOTENAI
BENEWAH
SHOSHONE
LATAH
CLEARWATER
NEZ PERCE
LEWIS
IDAHO
ADAMS
VALLEY
WASHINGTON
PAYETTE
GEM
BOISE
CANYON
ADA
ELMORE
CUSTER
LEMHI
CLARK
FREMONT
BUTTE
JEFFERSON
MADISON
TETON
BLAINE
CAMAS
BONNEVILLE
GOODING
LINCOLN
JEROME
MINIDOKA
OWYHEE
TWIN FALLS
CASSIA
POWER
CARIBOU
BEAR LAKE
FRANKLIN
ONEIDA
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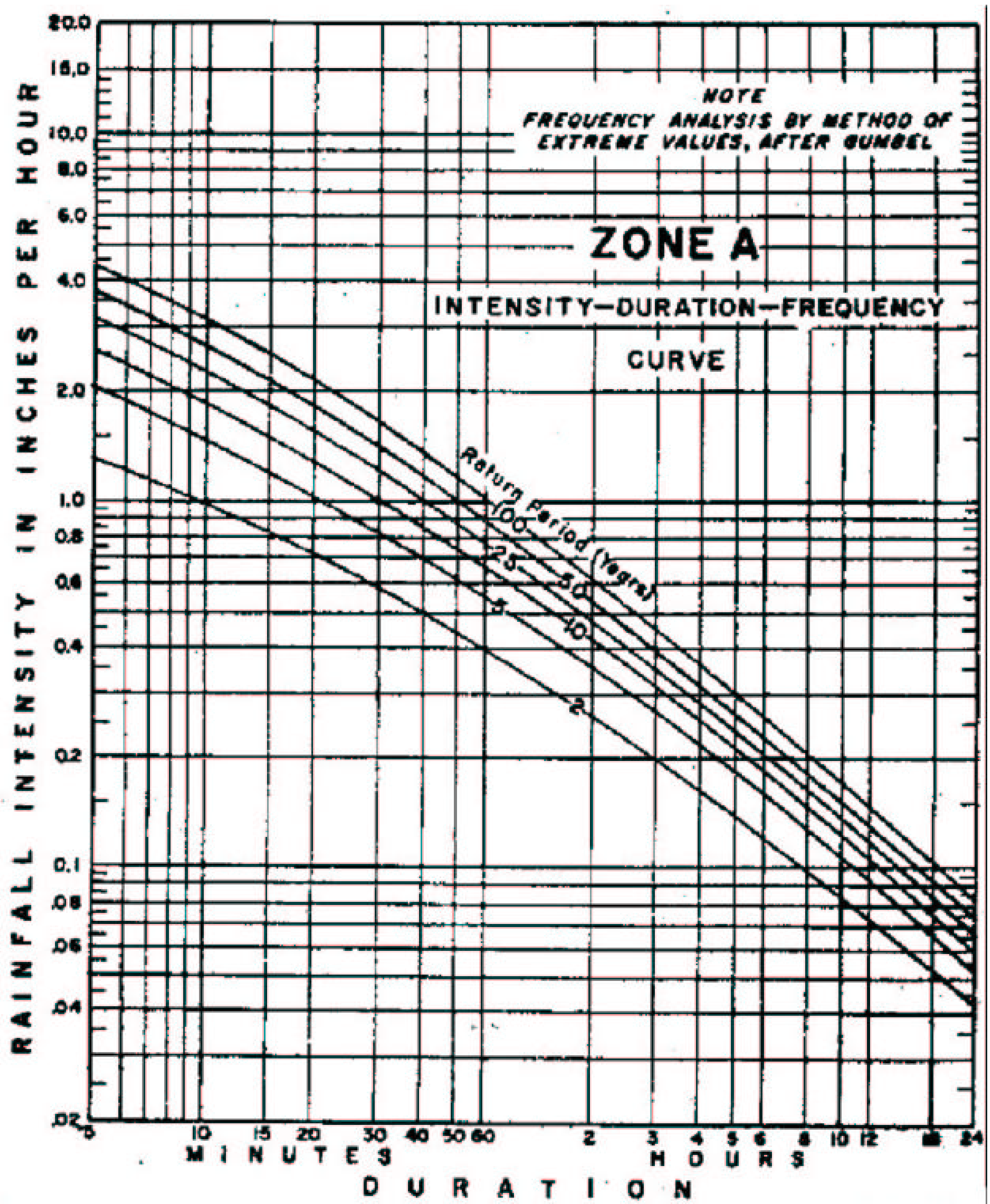
5
6


NOTE
FREQUENCY ANALYSIS BY METHOD OF EXTREME VALUES, AFTER GUMBEL
ZONE A
INTENSITY—DURATION—FREQUENCY
CURVE
Return Period (Years)
100
50
25
10
5
2
RAINFALL INTENSITY IN INCHES PER HOUR
20.0
16.0
10.0
8.0
6.0
4.0
2.0
1.0
0.8
0.6
0.4
0.2
0.1
.08
.06
.04
.02
5
10
15
20
30
40
50
60
2
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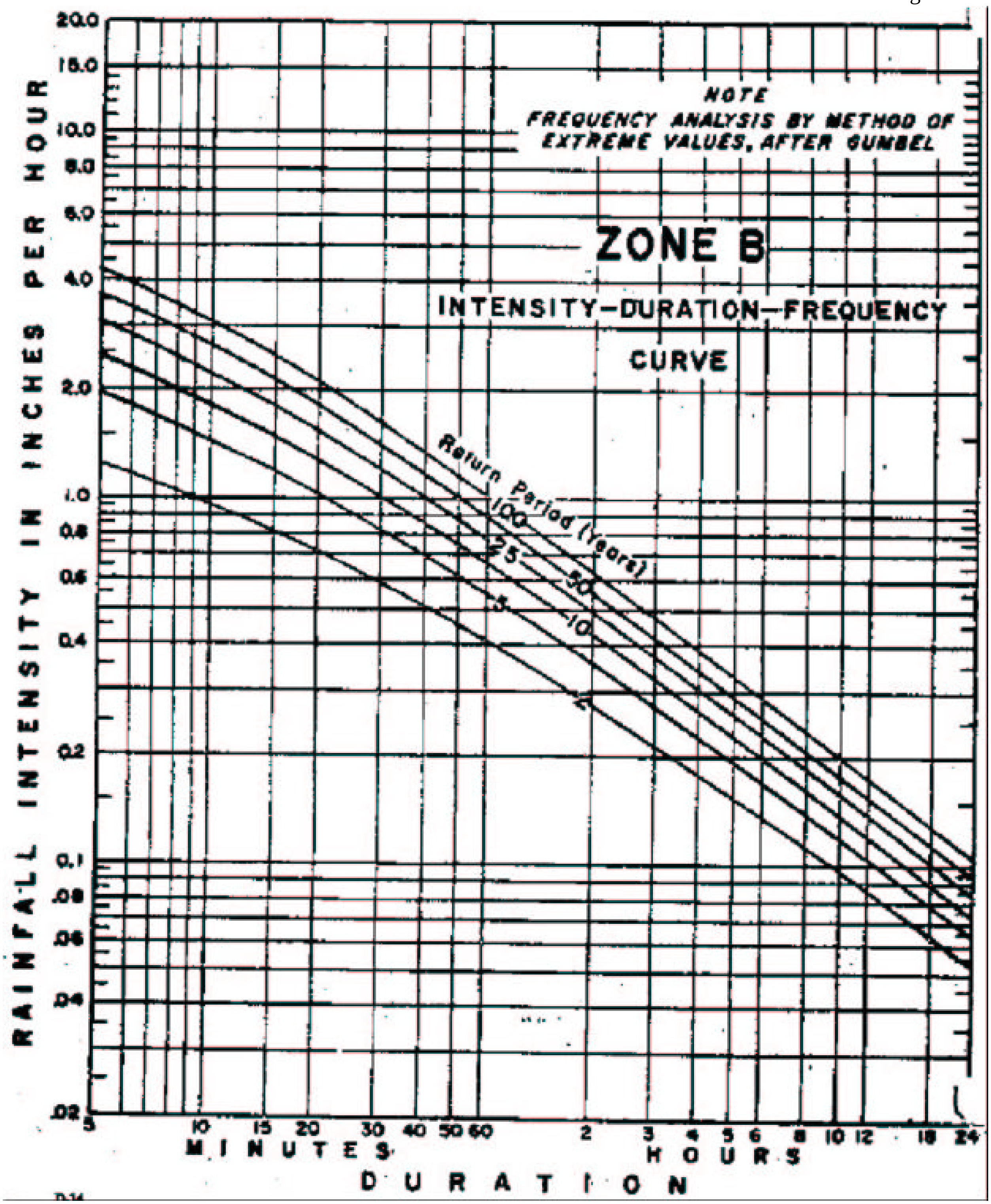
4
5
6
8
10
12
18
24
MINUTES
HOURS
DURATION


NOTE
FREQUENCY ANALYSIS BY METHOD OF EXTREME VALUES, AFTER GUMBEL
ZONE B
INTENSITY—DURATION—FREQUENCY
CURVE
Return Period (Years)
100
50
25
10
5
2
RAINFALL INTENSITY IN INCHES PER HOUR
20.0
15.0
10.0
8.0
6.0
4.0
2.0
1.0
0.8
0.6
0.4
0.2
0.1
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.04
.02
5
10
15
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40
50
60
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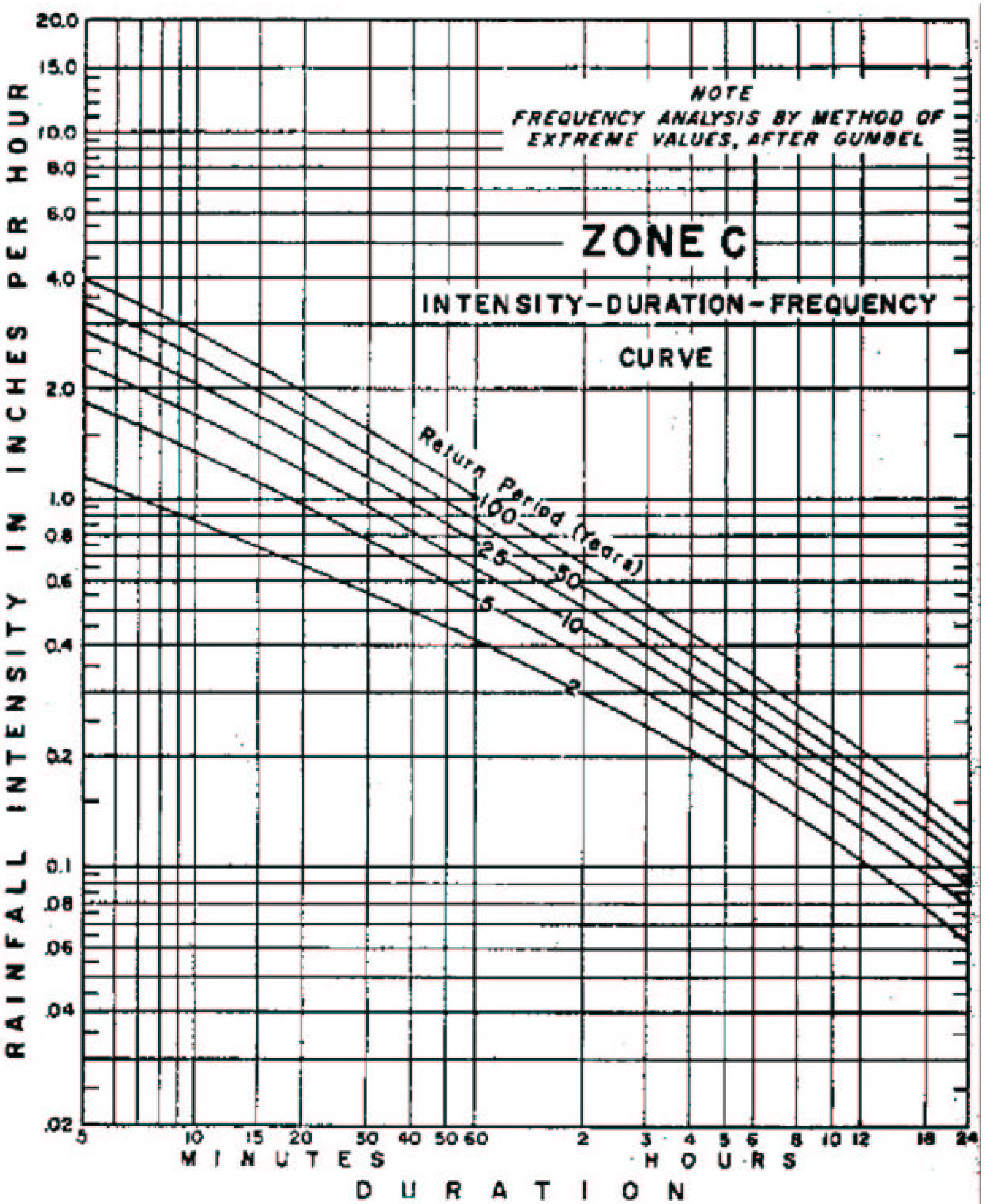
4
5
6
8
10
12
18
24
MINUTES
HOURS
DURATION


NOTE
FREQUENCY ANALYSIS BY METHOD OF EXTREME VALUES, AFTER GUMBEL
ZONE C
INTENSITY-DURATION-FREQUENCY
CURVE
Return Period (Years)
100
50
25
10
5
2
RAINFALL INTENSITY IN INCHES PER HOUR
20.0
15.0
10.0
8.0
6.0
4.0
2.0
1.0
0.8
0.6
0.4
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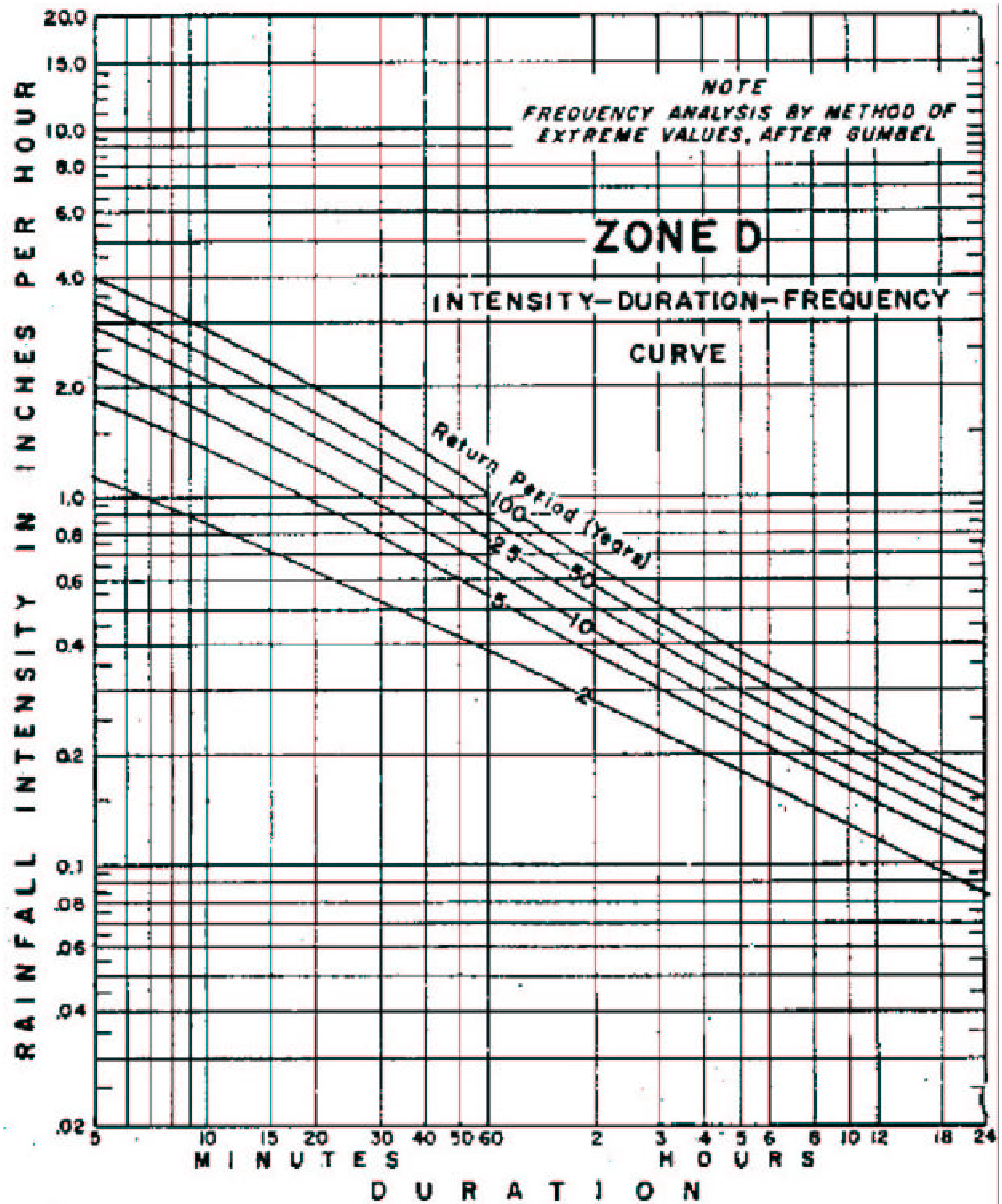
MINUTES
HOURS
DURATION


NOTE
FREQUENCY ANALYSIS BY METHOD OF
EXTREME VALUES, AFTER GUMBEL
ZONE D
INTENSITY—DURATION—FREQUENCY
CURVE
Return Period (Years)
100
50
25
10
5
2
RAINFALL INTENSITY IN INCHES PER HOUR
20.0
15.0
10.0
8.0
6.0
4.0
2.0
1.0
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0.6
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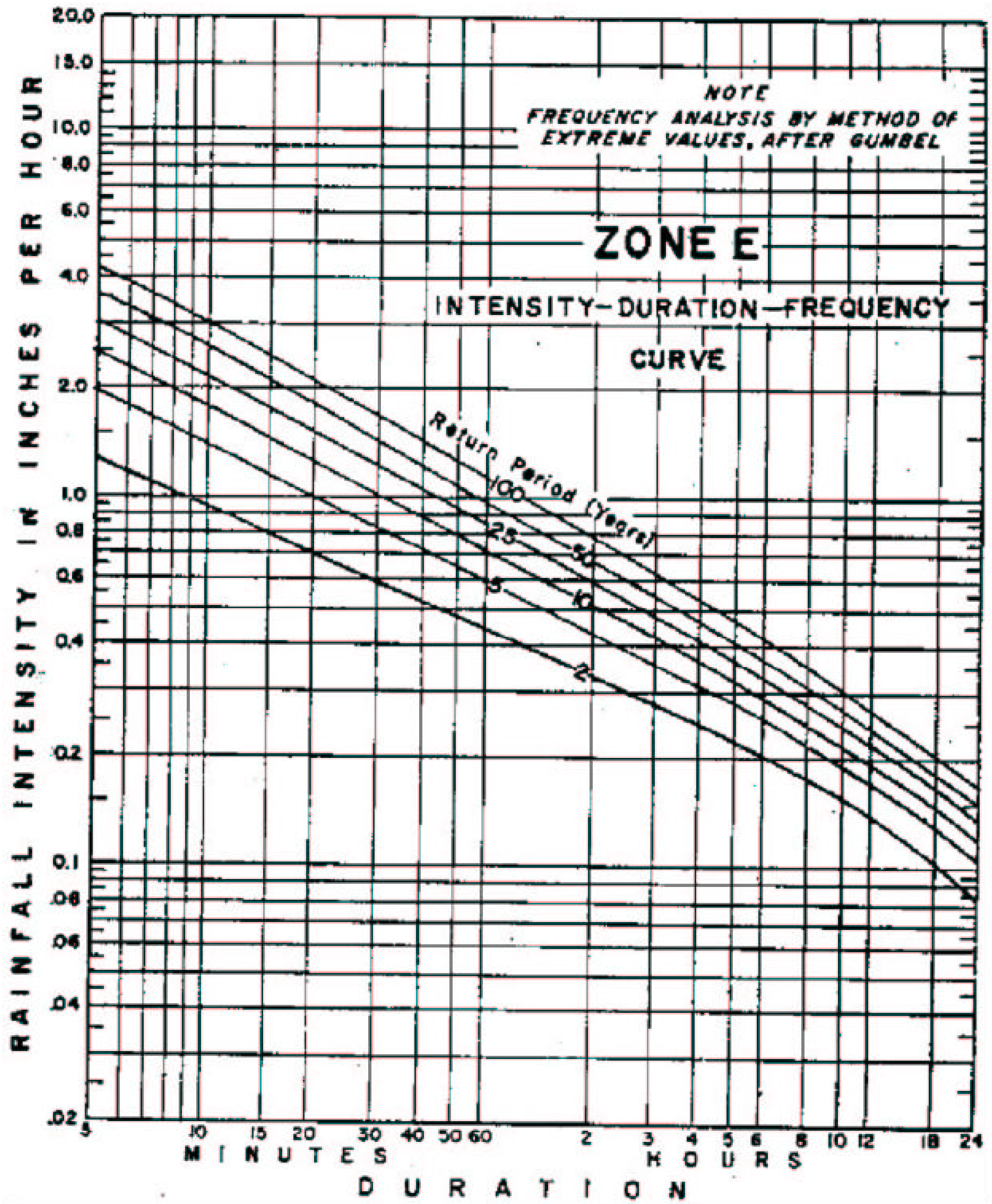
24
MINUTES
HOURS
DURATION


NOTE
FREQUENCY ANALYSIS BY METHOD OF EXTREME VALUES, AFTER GUMBEL
ZONE E
INTENSITY–DURATION–FREQUENCY
CURVE
Return Period (Years)
100
50
25
10
5
2
RAINFALL INTENSITY IN INCHES PER HOUR
20.0
15.0
10.0
8.0
6.0
4.0
2.0
1.0
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0.4
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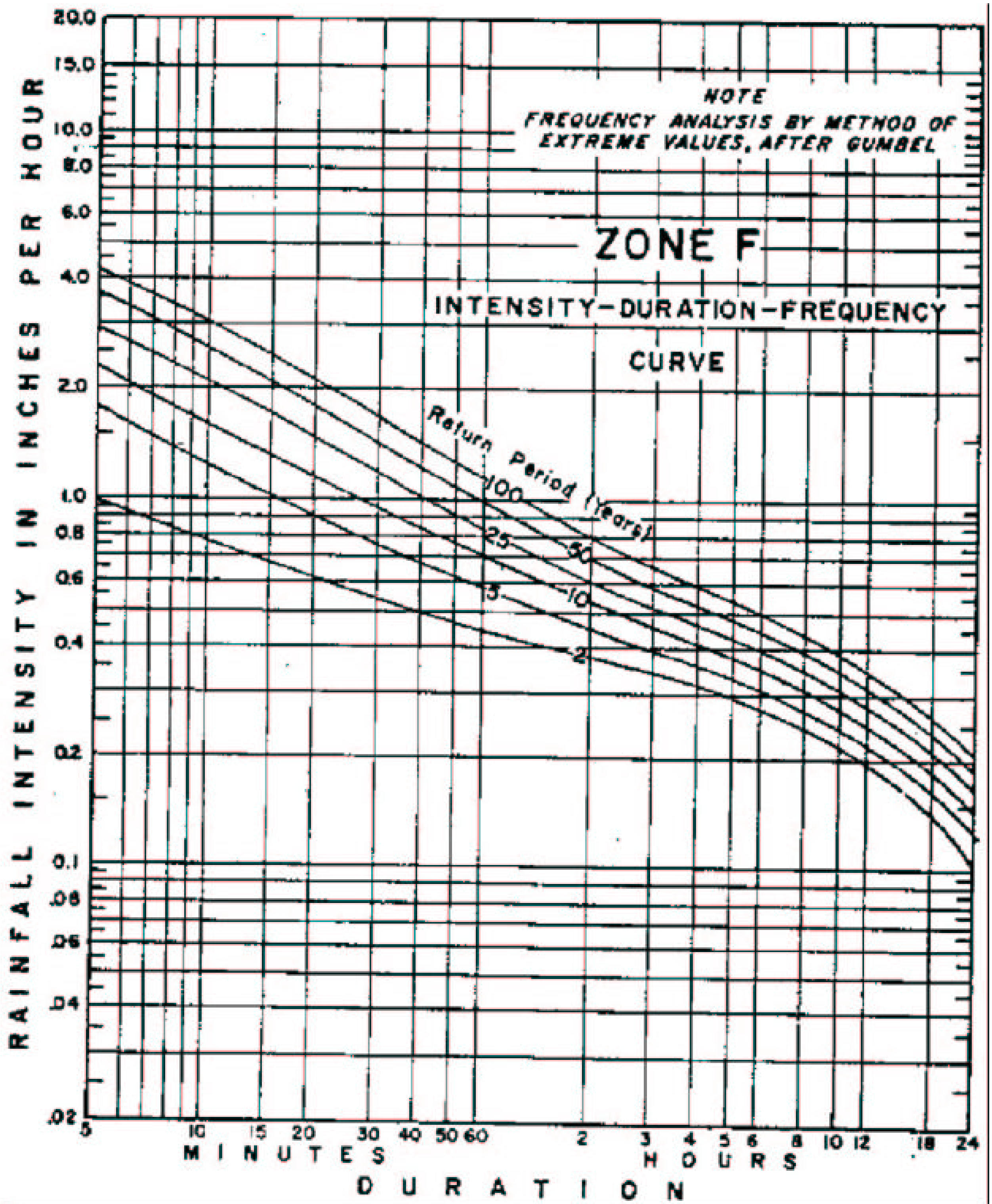
MINUTES
HOURS
DURATION


NOTE
FREQUENCY ANALYSIS BY METHOD OF EXTREME VALUES, AFTER GUMBEL
ZONE F
INTENSITY-DURATION-FREQUENCY
CURVE
Return Period (Years)
100
50
25
10
5
2
RAINFALL INTENSITY IN INCHES PER HOUR
20.0
15.0
10.0
8.0
6.0
4.0
2.0
1.0
0.8
0.6
0.4
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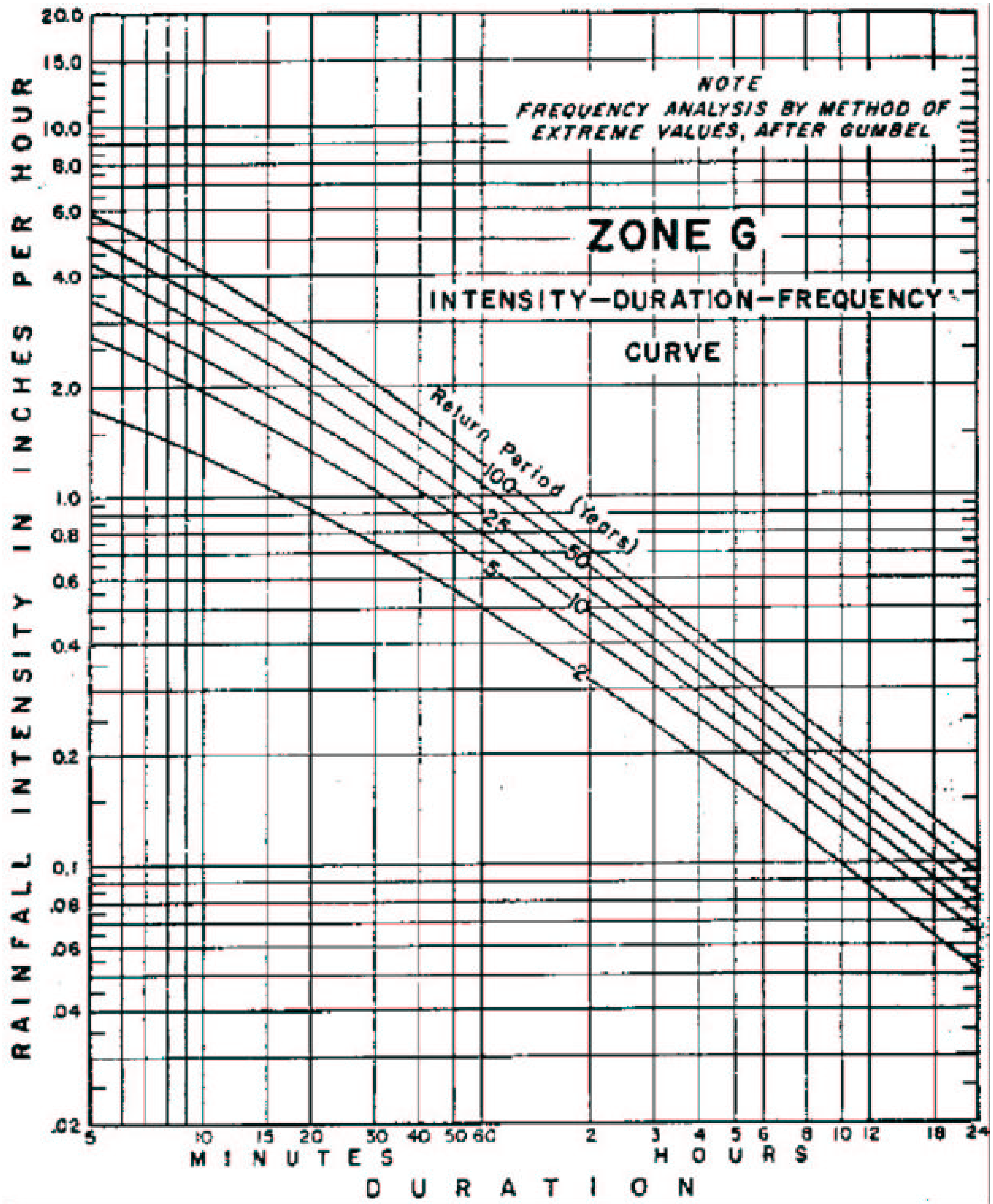
MINUTES
HOURS
DURATION


NOTE
FREQUENCY ANALYSIS BY METHOD OF EXTREME VALUES, AFTER GUMBEL
ZONE G
INTENSITY—DURATION—FREQUENCY CURVE
Return Period (Years)
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50
25
10
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2
RAINFALL INTENSITY IN INCHES PER HOUR
20.0
15.0
10.0
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6.0
4.0
2.0
1.0
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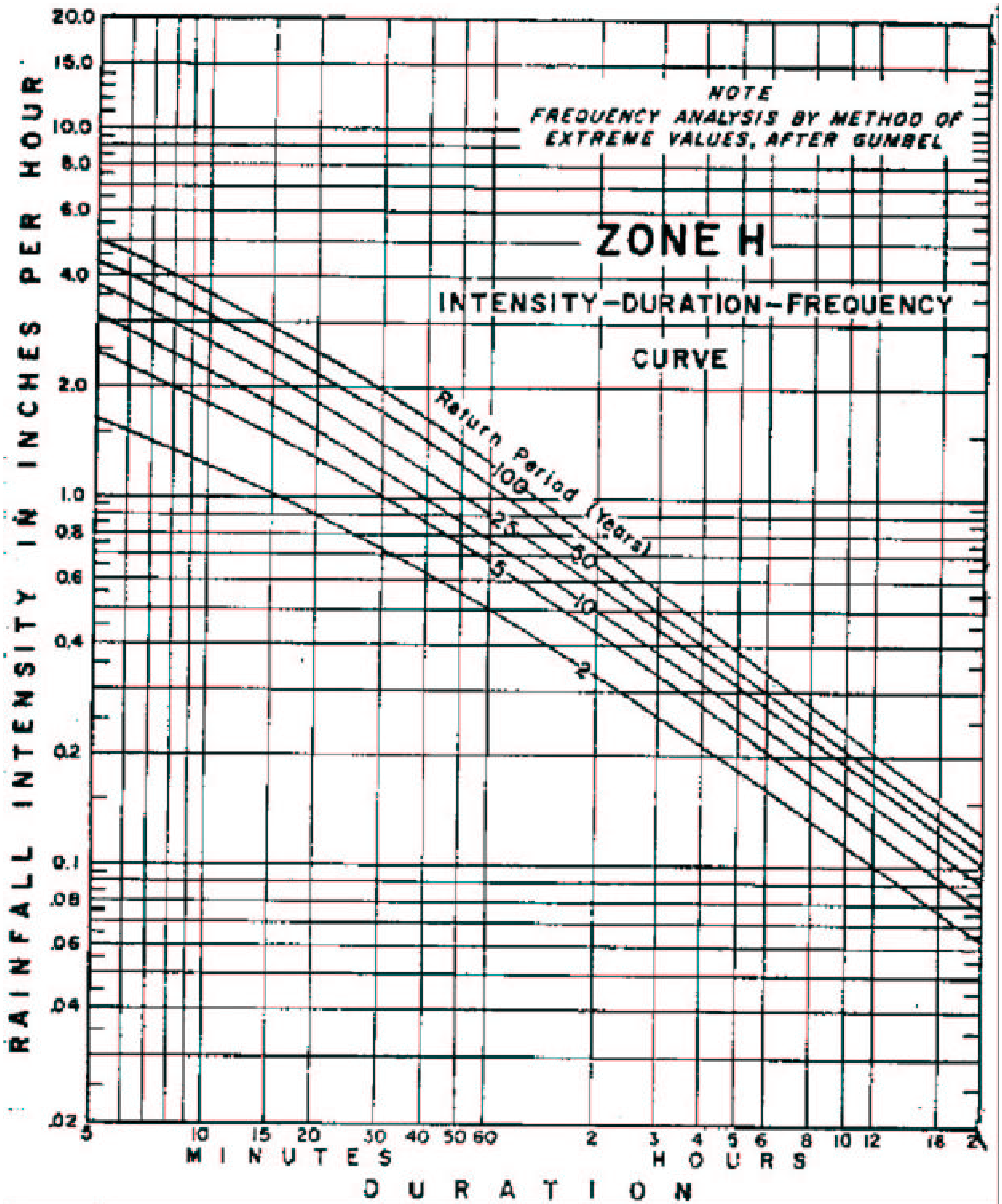
MINUTES
HOURS
DURATION


NOTE
FREQUENCY ANALYSIS BY METHOD OF
EXTREME VALUES, AFTER GUMBEL
ZONE H
INTENSITY-DURATION-FREQUENCY
CURVE
Return Period (Years)
100
50
25
10
5
2
RAINFALL INTENSITY IN INCHES PER HOUR
20.0
15.0
10.0
8.0
6.0
4.0
2.0
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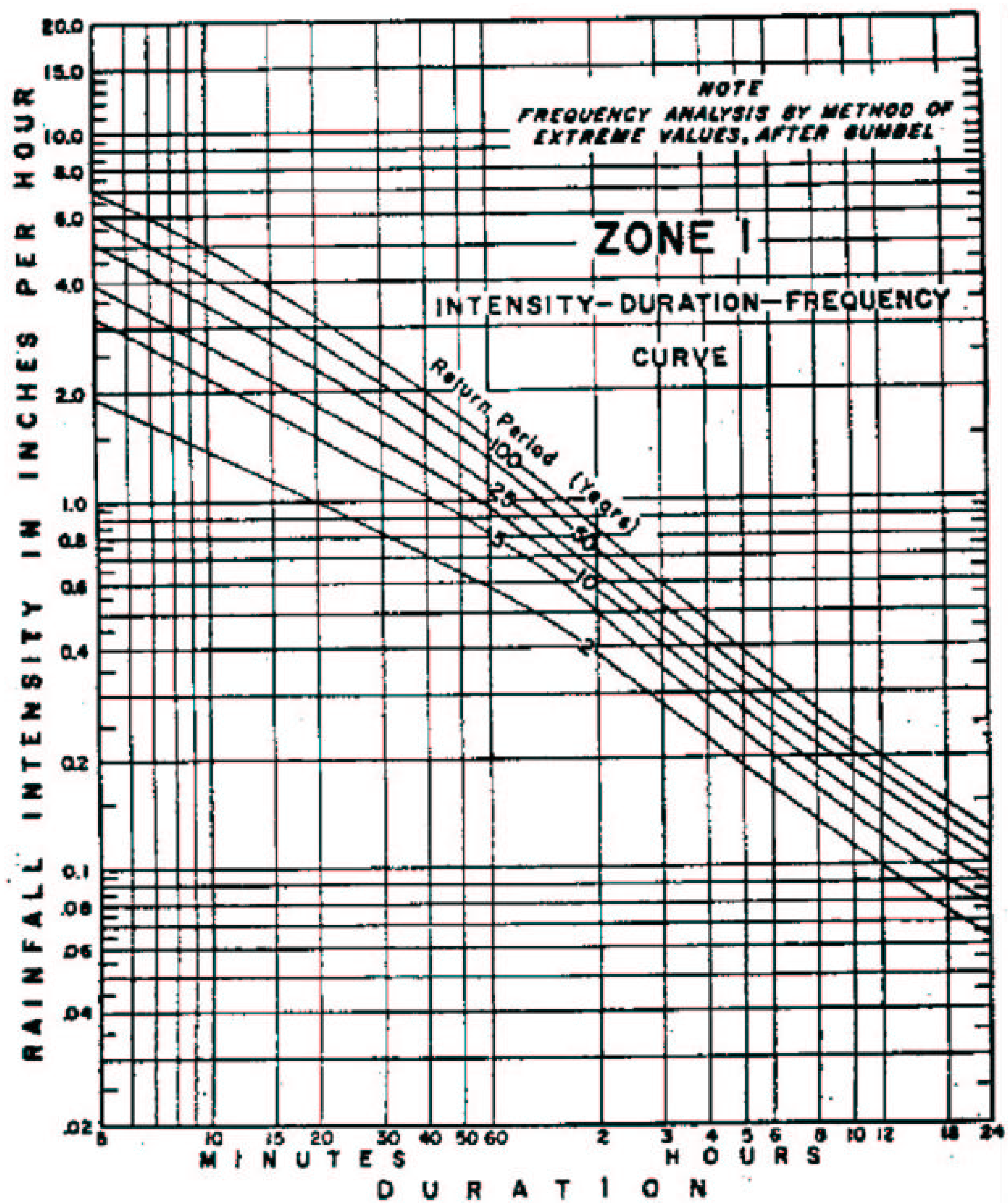
MINUTES
HOURS
DURATION


NOTE
FREQUENCY ANALYSIS BY METHOD OF
EXTREME VALUES, AFTER GUMBEL
ZONE I
INTENSITY—DURATION—FREQUENCY
CURVE
Return Period (Years)
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RAINFALL INTENSITY IN INCHES PER HOUR
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5
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18
24
MINUTES
HOURS
DURATION

B.40 – REGIONAL REGRESSION METHODS

Four technical reports are summarized.

B.40.01 Estimating the Magnitude of Peak Flows at Selected Recurrence Intervals for Streams in Idaho; Water-Resource Investigations 02-4170.

U.S. Department of the Interior
U.S. Geological Survey

Prepared in cooperation with
IDAHO TRANSPORTATION DEPARTMENT
IDAHO BUREAU OF DISASTER SERVICES
U.S. ARMY CORPS OF ENGINEERS

Estimating the Magnitude of Peak Flows at Selected Recurrence Intervals for Streams in Idaho

Water-Resources Investigations Report 02–4170

science for a changing world

Estimating the Magnitude of Peak Flows at Selected Recurrence Intervals for Streams in Idaho

By Charles Berenbrock

Water-Resources Investigations Report 02–4170

Prepared in cooperation with
IDAHO TRANSPORTATION DEPARTMENT
IDAHO BUREAU OF DISASTER SERVICES
U.S. ARMY CORPS OF ENGINEERS

Boise, Idaho
2002

U.S. DEPARTMENT OF THE INTERIOR
Gale A. Norton, Secretary

U.S. GEOLOGICAL SURVEY
Charles G. Groat, Director

Additional information can be obtained from:

District Chief
U.S. Geological Survey
230 Collins Road
Boise, ID 83702-4520
http://idaho.usgs.gov

Copies of this report can be purchased from:

U.S. Geological Survey
Information Services
Box 25286
Federal Center
Denver, CO 80225
e-mail: infoservices@usgs.gov

Copies of this report also are available in PDF format, which can be viewed using Adobe Acrobat Reader, at URL:
http://idaho.usgs.gov/public/reports.html

CONTENTS

FIGURES

TABLES

CONVERSION FACTORS, VERTICAL DATUM, AND WATER YEAR DEFINITION

Multiply	By	To obtain
cubic foot per second (ft^3/s)	0.02832	cubic meter per second
foot (ft)	0.3048	meter
foot per mile (ft/mi)	0.1894	meter per kilometer
inch (in.)	2.54	centimeter
mile (mi)	1.609	kilometer
square mile (mi^2)	2.590	square kilometer

Sea level: In this report, “sea level” refers to the North American Vertical Datum of 1988 (NAVD of 1988)—a vertical control datum established by the minimum-constraint adjustment of Canadian-Mexican-United States leveling observations and held fixed at Father Point/Rimouski, Quebec, Canada.

Water year: In U.S. Geological Survey reports dealing with surface-water supply, a water year is the 12-month period, October 1 through September 30. The water year is designated by the calendar year in which it ends; thus, the water year ending September 30, 2002, is called the “2002 water year.”

Estimating the Magnitude of Peak Flows at Selected Recurrence Intervals for Streams in Idaho

By Charles Berenbrock

Abstract

Methods for estimating magnitudes of peak flows at various recurrence intervals, needed for highway-structure and water-control design and planning, were developed for gaged and ungaged sites on streams throughout Idaho. Recurrence intervals of 2, 5, 10, 25, 50, 100, 200, and 500 years were selected for analysis of peak flows.

For gaged sites in Idaho, peak-flow estimates were calculated by fitting a log-Pearson Type III distribution to the annual peak-flow data for each site. Annual peak flows through 1997 were used in the analysis. Basin and climatic characteristics for these gaged sites were calculated from 1:24,000 digital-elevation models and various thematic data coverages using a geographic information system. Peak-flow data and basin and climatic characteristics for 333 gaged sites were combined to develop a database that was used for the analysis. To estimate the magnitude of peak flows at ungaged sites near gaged sites on the same stream, a method was developed on the basis of drainage-area ratios.

To estimate the magnitude of peak flows for ungaged sites on unregulated and undiverted streams, two regional regression methods were developed. The first regression method, termed the regional regression method, used generalized least-squares regression to develop a set of predictive equations for estimating peak flows at selected recurrence intervals for seven hydrologic regions in Idaho. These regional regression equations related basin and climatic characteristics to peak flows. The regional regression equations were all functions of drainage area plus one or two other basin characteristics. Average errors of prediction for these regression equations ranged from +143 percent to -58.8 percent. The range of errors was narrowest, from about +51.9 to about -34.2, for region 5. Error ranges were usually narrower for the middle recurrence intervals than for the lower and upper recurrence intervals. A computer program was developed to calculate the magnitude of peak flows at each recurrence interval, the average error of prediction, and the 90-percent confidence interval for each ungaged site.

The second regression method, termed the region-of-influence method, was used to develop a unique regression equation for each estimate that is based on a subset of gaged sites with values of basin and climatic characteristics similar to those for the ungaged sites. All 333 gages in the database were used to select the subset. Root-mean-squared errors for this method ranged from 55.5 percent to 72.4 percent. Differences in root-mean-squared errors between regional regression equations and the region-of-influence method were quite large. The average difference in root-mean-squared errors for the region-of-influence method was more than 10 percent greater than the average differences for the regional regression equations. For region 5, the average difference was greater than 20 percent. However, for region 8, the root-mean-squared errors were, in general, only slightly smaller for the region-of-influence method than for the regional regression equations. The region-of-influence method is not recommended for use in determining flood-frequency estimates for ungaged sites in Idaho because the results, overall, are less accurate and the calculations are more complex than those of regional regression equations. The regional regression equations were considered to be the primary method of estimating the magnitude and frequency of peak flows for ungaged sites in Idaho.

INTRODUCTION

Reliable estimates of the magnitude and frequency of floods (termed peak flows in this report) are needed by Federal, State, regional, and local designers and managers. The design of highway, road, and railroad stream crossings; delineation of flood plains and floodprone areas; management of water-control structures; and management of irrigation and water supplies are all activities that require estimates of the frequency distributions, or recurrence intervals, of peak flows. Such estimates can be calculated directly by using statistical methods for gaged sites (sites where streamflow-gaging stations, or gages, have been established) that have at least 10 years of annual peak-flow record (Riggs, 1972; Interagency Advisory Committee on Water Data, 1982). Longer records usually result in more reliable estimates. It is not feasible, however, to collect 10 years of annual peak-flow records for every location where an estimate of the flood-frequency distribution is needed, nor is it reasonable to wait 10 years for an estimate once a site has been identified.

Accurate estimates of peak-flow magnitudes at various frequencies are necessary for effective structural design and planning purposes. Underestimating peak flows can result in loss of life, disruption of service, and costly maintenance, and overestimates can result in excessive construction cost. Unfortunately, design and planning activities often require peak-flow magnitude and frequency information for locations where there are inadequate or no peak-flow data. To meet information needs for design and planning, estimates of the magnitude of annual peak flows for gaged sites have been regionalized. This process relates flood frequencies estimated for gaged sites to measurable basin and climatic or channel-geometry characteristics so that reliable flood frequencies can be estimated for ungaged sites by use of regression equations. Flood-frequency studies have been conducted within Idaho since the 1970s (see “Previous Studies” section). Often, the area of study was subdivided into regions of similar hydrology (hydrologic regions) to improve the predictive ability of the regression equations.

In 1998, the U.S. Geological Survey (USGS) conducted a study in cooperation with the Idaho Transportation Department (ITD), Idaho Bureau of Disaster Services (BDS), and U.S. Army Corps of Engineers (COE) to develop regional regression equations that would define the relation between peak flows and basin characteristics. The equations and the estimating methods used in this study will provide more accurate estimates of peak flows for Idaho than provided in previous reports because of the use of additional data and availability of more robust statistical methods.

Purpose and Scope

This report documents estimation of the magnitude of peak flows at recurrence intervals of 2, 5, 10, 25, 50, 100, 200, and 500 years. Two methods, the log-Pearson Type III distribution and the drainage-area ratio, are presented for estimating peak flows for gaged sites and for ungaged sites near gaged sites on the same stream. Two methods based on regression analysis are presented for estimating peak flows for ungaged sites on unregulated and undiverted streams in Idaho—the regional regression method and the region-of-influence method. Standard errors of estimate were calculated to show the predictive reliability of each method, and the results were compared to evaluate their applications and limitations. To compare the two methods on an equal basis, each method was applied to the same dataset, which consisted of 333 gaged sites with at least 10 years of unregulated, undiverted peak-flow record. Information in this report describing peak-flow compilation and methods for estimating peak flows for ungaged sites was derived mainly from documentation of a similar study in North Carolina by Pope and Tasker (1999).

For information on estimating peak flows in urbanized drainage basins, the reader is referred to a national study by Sauer and others (1983). Techniques for estimating peak flows for ungaged sites on regulated streams were beyond the scope of this report.

Acknowledgments

The author recognizes the hard work and dedication of the many USGS hydrologic technicians in collecting, processing, and storing the peak-flow data necessary for the completion of this report. Also, the author appreciates the assistance of the many Federal, State, and local agencies that financially supported operation of gages throughout Idaho where peak-flow data are collected. Special recognition goes to Gary Tasker, USGS, who provided a computer program for use in this study.

Previous Studies

Thomas and others (1973) were the first to develop regional regression equations for estimating flood-frequency characteristics for Idaho streams. Their regression equations only directly determined the 10-year peak flow (Q_{10}). Ratios were used to estimate the 25-

year (Q_{25}) and 50-year peak flows (Q_{50}). Standard errors for Q_{10} ranged from 41 to 62 percent (table 1). Their equations were applicable only for streams draining areas between 0.5 and 200 mi^2. In their analysis, the State was divided into nine regions and separate regression equations and ratios were developed for each. The following basin characteristics were used in one or more of their equations: basin area, percent forest area, percent water area, and latitude and longitude. Harenberg (1980) developed several sets of regression equations for Idaho on the basis of channel-geometry and basin characteristics. The characteristics used in his study were bankfull width, drainage area, and the 24-hour rainfall intensity for the 2-year recurrence interval. He used fewer than half of the gaging stations used in the previous study because channel-geometry characteristics could not be determined at every gage. He demonstrated that standard errors were smaller when channel-geometry variables were included with basin characteristics in regression equations, but standard errors in his study were 20 to 30 percent larger than in the previous study (table 1), which used a dataset twice as large.

Using peak-flow data through 1977, Kjelstrom and Moffatt (1981) developed regional regression equations using the method of moments. About 270 gages were used and the State was divided into three regions. Their equations used one or more of the following basin characteristics to calculate the logarithmic mean and logarithmic standard deviation: drainage area, mean basin elevation, percent forest cover, slope of the main channel, mean annual precipitation in the basin, mean minimum January temperature of the basin, and the 24-hour rainfall intensity for a 2-year recurrence interval. The frequency factor for the selected recurrence interval then was multiplied by the logarithmic standard deviation and added to the logarithmic mean to obtain the logarithmic magnitude of peak flow.

Table 1. Average standard errors of prediction for selected peak-flow recurrence intervals estimated by using regional regression equations from previous studies in Idaho

[Q_{10}, peak flow with a recurrence interval of 10 years; Q_{25}, peak flow with a recurrence interval of 25 years; Q_{50}, peak flow with a recurrence interval of 50 years; Q_{100}, peak flow with a recurrence interval of 100 years; min, minimum value; max, maximum value; —, no regional regression equations were available for the indicated recurrence interval]

Peak flow		Average standard errors of prediction, in percent						
		Thomas and others (1973)	Harenberg (1980)	Kjelstrom and Moffatt (1981)	Quillian and Harenberg (1982)	Hedman and Osterkamp (1982)	Thomas and others (1994)	This study
Q_{10}	min	41	71	[1]41	49	[2]60	66	41
	max	62	92	[1]90	107		95	77
Q_{25}	min	—	71	[1]41	—	[2]62	66	40
	max	—	92	[1]90	—		90	75
Q_{50}	min	—	71	[1]41	46	[2]71	72	41
	max	—	91	[1]90	118		89	72
Q_{100}	min	—	72	[1]41	49	[2]83	77	41
	max	—	91	[1]90	123		90	72

[1]The same average standard error of prediction was applicable to all peak-flow estimates.
[2]Only the average error was available.

The antilogarithm then was applied to obtain the magnitude of peak flow. Standard errors of estimate in their study ranged from 41 to 90 percent (table 1).

In a network and cost-estimate analysis of gages in Idaho, Quillian and Harenberg (1982) developed regional regression equations for nine regions in the State. They used the same regions as in the first regional regression study by Thomas and others (1973). They developed equations for the 2-, 10-, 50-, and 100-year peak flows and the mean annual flow. Their equations were based on basin characteristics, and standard errors were larger than errors from the three previous regional regression studies. Hedman and Osterkamp (1982) also developed regional regression equations for selected peak flows and for the mean annual flow for the western half of the United States. Their equations were based on channel-geometry characteristics, and drainage basins in the State were grouped into a much larger region composed of the Rocky Mountains. However, data from only three gages in Idaho were used in their analysis. These gages were located on tributaries to the Snake River. Standard errors were within the ranges of error from the previous studies (table 1).

Thomas and others (1994) developed regional regression equations for 16 regions in the southwestern United States. Only the southern part of Idaho was included in their analysis, which comprised four regions. The eastern and western Snake River Plain regions composed most of the area. Basin and climatic characteristics (basin area, mean elevation, and (or) mean annual precipitation) also were needed to determine the peak flow at the selected recurrence interval. They used peak-flow data through 1991. Standard errors for their study were similar to those from previous studies that used basin and climatic characteristics (table 1).

General Description of Study Area

The landscape of Idaho is quite diverse, with areas of flat, extensive plains, rolling hills, and rugged mountains. Land-surface elevations range from 14,000 ft above sea level at Borah Peak to about 1,800 ft at Porthill, in the northern part of the State. A prominent geographic feature of Idaho is the Snake River Plain, which bisects the southern part of the State. Volcanic rocks and alluvium underlie the plain and, in the eastern part, much of the volcanic rock is exposed. In the western part of the plain, however, the alluvium is thousands of feet thick. Land use in the plain is mostly desert shrubs and large tracts of irrigated lands. Most of the State north of the Snake River Plain is in the Rocky Mountains and is underlain principally by granitic rocks. Land use in this area is dominated by forest and woodland, except in the area between Coeur d’Alene Lake and the Clearwater River, where cropland is the major land use.

Annual precipitation varies widely in the State, primarily because of orographic effects. Annual precipitation tends to be greatest in the mountains, where it is as much as 70 in. in the northern and central mountains that border Montana (Molnau, 1995). Valley areas tend to be drier than adjacent mountains, especially in Birch Creek and Big Lost, Little Lost, Pahsimeroi, and Lemhi River Valleys. In the Snake River Plain, annual precipitation is less than 10 in.

Annual runoff generally follows the precipitation pattern, and quantities are larger in areas of higher elevation. Streamflows vary greatly on a seasonal basis, as snowmelt provides the bulk of annual runoff in May, June, and July for mountain streams and in March, April, and May for streams draining the lower foothills and valley-floor areas. Streamflows generally are smallest in late fall and winter, and many streams can become dry during this period.

The major drainage basins in Idaho are the Snake, Salmon, Clearwater, Spokane, Pend Oreille, and Kootenai River Basins, which are all within the Columbia River Basin. The Snake River drains most of the southern half of the State (fig. 1). Near King Hill, more than 5,000 ft^3/s discharges to the Snake River from ground water (Kjelstrom, 1995). The Snake River winds westward through the Snake River Plain until it reaches Oregon, then heads northward to the city of Lewiston, Idaho (fig. 1). In central Idaho, the Salmon River joins the Snake River at the Idaho-Oregon boundary about 40 mi south of Lewiston, and the Clearwater River joins the Snake River at Lewiston. In northern Idaho, the Coeur d’Alene River flows westward to Coeur d’Alene Lake. The lake’s outlet drains to the Spokane River, which flows westward from Idaho to Washington and joins the Columbia River. The Clark Fork flows from Montana into Idaho and into Pend Oreille Lake. The lake’s outlet drains to the Pend Oreille River, which winds westward through Idaho to Washington and joins the Columbia River. The Kootenai River flows northwestward from Montana through a small area of Idaho to Canada and joins the Columbia River.

PEAK-FLOW COMPILATION

The first step in the regionalization of flood-frequency estimates is compilation of a list of all gaged sites with annual peak-flow records. Such sites are either continuous-record sites or crest-stage sites. At continuous-record sites, the water-surface elevation, or stage, of the stream is recorded at fixed intervals, typically ranging from 5 to 60 minutes. At crest-stage sites, only the crest, or highest stages that occur between site visits (usually several months) are recorded. Regardless of the type of gage, discharge measurements are made throughout the range of recorded stages, and a relation between stage and discharge is developed for the gaged site. Using this stage-discharge relation, or rating, discharges for all recorded stages are determined. The highest peak discharge that occurs during a given year is the annual peak for the year, and the list of annual peaks is the annual peak-flow record.

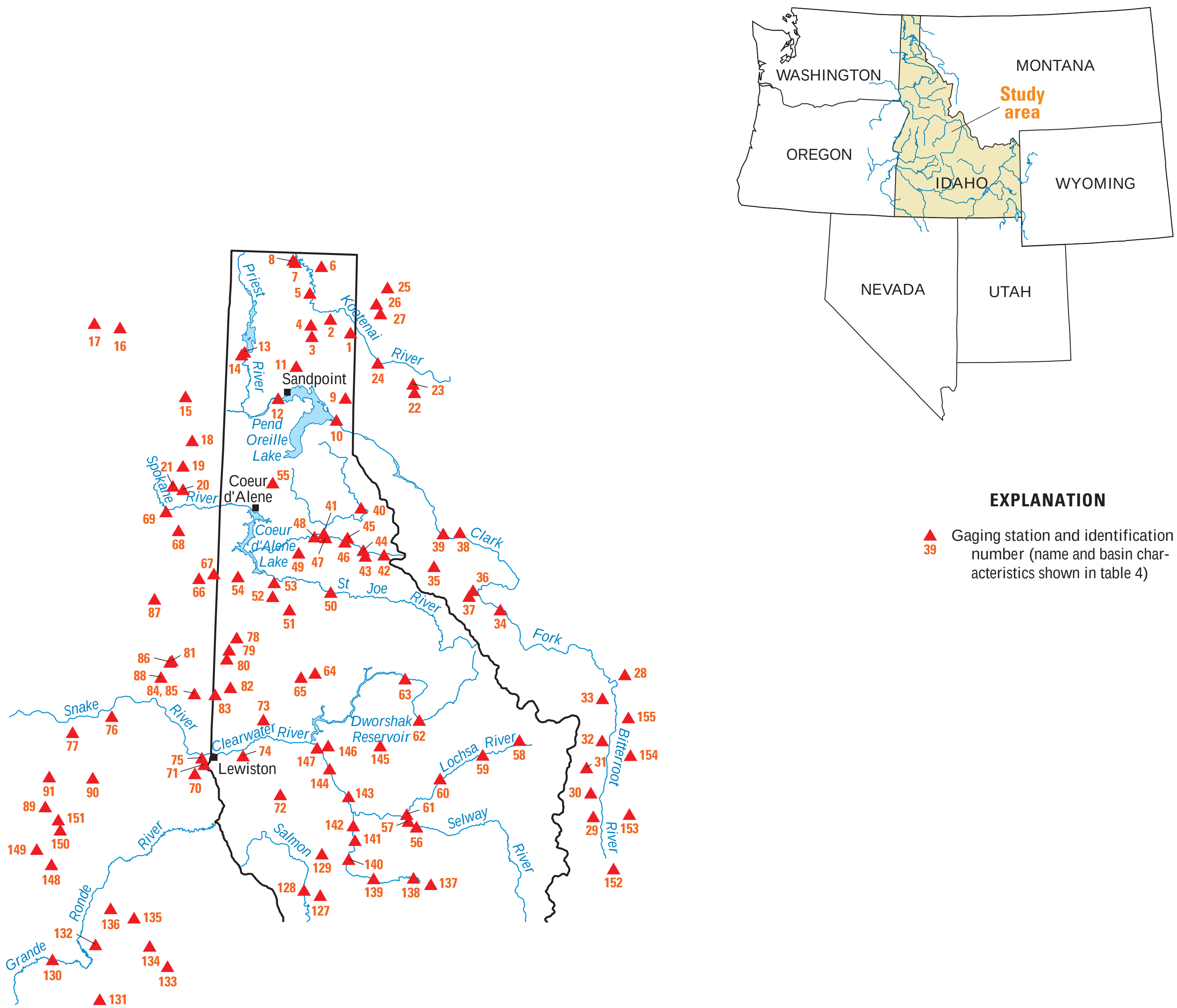
Initially, more than 500 gages, including gages from bordering States, were determined to have some annual peak-flow records. Examination of flow records for these gages revealed that many were on streams regulated by reservoirs or had irrigation diversion(s) that would significantly affect peak flows at the gage. These gages then were excluded from the database. Gages that did not have 10 or more years of peak-flow records were excluded from the database and not used in any subsequent calculations (Riggs, 1972; Interagency Advisory Committee on Water Data, 1982). Flood-frequency characteristics for the remaining 333 gages (fig. 1) were calculated and formed the database that was used for the regional regression and region-of-influence methods.

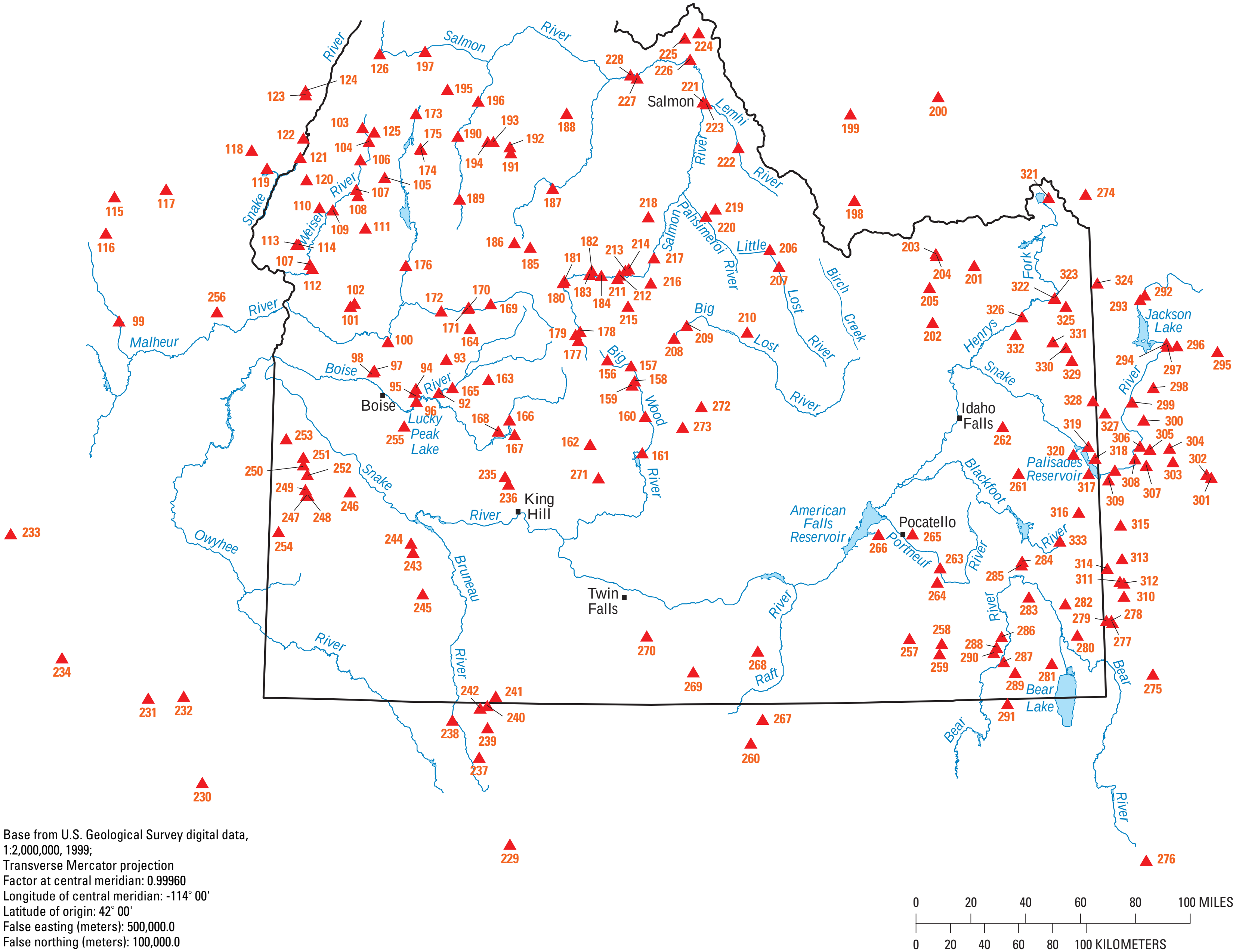
BASIN AND CLIMATIC CHARACTERISTICS

Because basin and climatic characteristics are widely used in regression equations, several basin and climatic variables have been measured previously at most USGS gages in Idaho and bordering States. These data were stored in the Basin Characteristics File of the USGS Water Data Storage and Retrieval System (WATSTORE) and were determined by measuring the characteristic on the largest scaled (most detailed) topographic map available. For example, drainage area was determined by manually planimetering the outline of the basin upstream from each gage and was usually done on 1:24,000-scale maps (USGS 7.5-minute quadrangle maps) to ensure consistency of the data. Other basin and climatic characteristics that were measured at some gages and stored in WATSTORE included basin perimeter, mean basin elevation, basin slope, basin relief, drainage density, and aspect.

Except for drainage area, basin and climatic characteristic data were not readily available for all gages used in this study. In addition, mean annual precipitation for each basin had to be reevaluated because more recent estimates throughout Idaho were available (Molnau, 1995). Because of the large number of sites involved and the need for consistent and unbiased methodology in making measurements and calculations, the Arc/Info geographic information system (GIS) was used to measure and calculate basin and climatic characteristics.

Therefore, all basin characteristics in this study, including the remeasurement of drainage area, were obtained using Arc Macro Language programs written for Arc/Info (Environmental Systems Research Institute, Inc., 1999). These programs generated the basin characteristic values from the datasets listed in table 2. More than 50 separate basin and climatic characteristics were obtained for each of the 333 gages included in the study. Several characteristics were removed from consideration after correlation plots of the data were reviewed. Generally, if two basin characteristics correlated well, the one that was the least difficult to obtain was kept and the other was removed from the database. Other characteristics were removed because of missing data or difficulty in obtaining data. By following this process, 18 basin and climatic characteristics were retained for use in the multiple-regression analysis. Of the 18 characteristics used in the analysis, 7 were included in at least one of the final equations. These 7 standard characteristics were: drainage area (DA), mean basin elevation (E), forested area (F), mean annual precipitation (P), basin slope (BS), north-facing slopes greater than 30 percent (NF30), and slopes greater than 30 percent (S30). Basin azimuth, area higher than 6,000 ft in elevation, slope of the main channel, length of the main channel, basin relief, basin perimeter, ruggedness number (basin relief divided by square root of drainage area), area of basin containing sedimentary rocks, area of basin containing granitic rocks, area of basin containing volcanic rocks, and minimum average temperatures also were included in the analysis but were not used in any of the equations. General descriptions of how the 7 basin and climatic characteristics used in the equations were measured are listed in table


WASHINGTON
MONTANA
OREGON
IDAHO
WYOMING
NEVADA
UTAH
Study area
Sandpoint
Coeur d'Alene
Lewiston
Priest River
Kootenai River
Pend Oreille Lake
Spokane River
Coeur d'Alene Lake
St Joe River
Clark Fork
Snake River
Clearwater River
Dworshak Reservoir
Lochsa River
Selway River
Salmon River
Bitterroot River
Grande Ronde River
EXPLANATION
Gaging station and identification number (name and basin characteristics shown in table 4)



Base from U.S. Geological Survey digital data,
1:2,000,000, 1999;
Transverse Mercator projection
Factor at central meridian: 0.99960
Longitude of central meridian: -114° 00'
Latitude of origin: 42° 00'
False easting (meters): 500,000.0
False northing (meters): 100,000.0

Figure 1. Locations of streamflow-gaging stations in Idaho and bordering States used in regional regression analysis.

Table 2. Selected data sources used to obtain basin and climatic characteristics for regional regression analysis

[Multiply meter by 3.281 to obtain foot; multiply kilometer (km) by 0.6214 to obtain mile]

Dataset name	Source description
National Elevation Dataset (NED)	Basin characteristics were calculated using 30-meter resolution digital elevation data **(http://gisdata.usgs.gov/ned/)**
National Elevation Dataset Hydrologic Derivatives (NED-H)	Hydrologic derivatives of NED data were developed using procedures similar to those in Stage 1 processing, using a custom projection for Idaho **(http://edcnts12.cr.usgs.gov/ned-h/about/Stage1.html)**
National Land Cover Dataset (NLCD)	Vogelmann, J.E., Sohl, T.L., Campbell, P.V., and Shaw, D.M., 1998, Regional land cover characterization using Landsat Thematic Mapper data and ancillary data sources: Environmental Monitoring and Assessment, v. 51, p. 415–428 **(http://edcwww.cr.usgs.gov/programs/lccp/)**
Idaho map of mean annual precipitation[1]	Molnau, M., 1995, Mean annual precipitation, 1961–1990, Idaho: Moscow, University of Idaho, Agricultural Engineering Department, State Climate Program, scale 1:1,000,000 **(http://snow.ag.uidaho.edu/Climate/reports.html)**
Western United States average monthly or annual precipitation[2]	Daly, C., and Taylor, G., 1998, Western United States average monthly or annual precipitation, 1961–90, Oregon: Portland, Water and Climate Center of the Natural Resources Conservation Service, grid-cell resolution 4 km **(http://www.ocs.orst.edu/prism/prism_new.html)**

[1]Used for areas in Idaho.
[2]Used for areas outside of Idaho.

3, and basin characteristic values obtained for the 333 gages (fig. 1) are presented in table 4.

All basin and climatic characteristics were calculated in a GIS using Arc/Info programs. For example, the DA program compares adjacent grid cells to develop an outline of the DA upstream from the point of interest on the stream using the 30-meter-resolution digital-elevation data (table 3). Then the program counts the number of cells within the DA and multiplies by 30 square meters to determine DA. To convert from square meters to square miles, the program multiplies DA by 3.861×10^{-7}. Because WATSTORE DA was available for most gages, the GIS-calculated DA then was compared with the WATSTORE DA, and the percent difference between GIS-calculated DA and WATSTORE DA was determined and used to help verify the delineation of basin boundaries. Sites with greater than 10-percent difference between the GIS-calculated and WATSTORE values were flagged and reexamined. Errors in the GIS boundary delineation were corrected by comparing USGS 7.5-minute topographic maps with the original manually planimetered basin boundary. After the GIS basin boundaries were adjusted, basin characteristics were recalculated and rechecked until satisfactory results were obtained. The final GIS-calculated DA is compared with the WATSTORE DA in figure 2. Several sites with DA fewer than 10 mi^2 did not meet the criteria of less than 10-percent difference between GIS-calculated DA and WATSTORE DA because the resolution of the GIS data was much finer (30 meters, or about 100 ft) than the map resolution. These sites were examined manually to determine whether the GIS delineation was consistent and correct; if not, the boundaries were adjusted accordingly and basin and climatic characteristics were recalculated. The GIS-calculated DA was determined to be appropriate and used for all sites in this study (table 4).

DETERMINATION OF REGIONS FOR REGIONAL REGRESSION ANALYSIS

In regional flood-frequency analysis, attempts are made to define regions that are hydrologically homogeneous in terms of the characteristics being studied (Haan, 1977). This helps to obtain a better fitting regression equation and reduces standard errors. In this study, eight regions were delineated on the basis of the following factors: (1) grouping of similar basin and climatic characteristics based on a statistical cluster analysis; (2) geographic features, such as large mountain ranges or breaks between mountains and plains; and (3) scientific judgment based on general knowledge of the area. Cluster analysis, which is a statistical technique that defines common areas on the basis of the similarity of variables used in the analysis, was used to delineate eight regions in Idaho. The cluster analysis was based on 17 of the 18 basin and climatic characteristics defined by the total variance explained by each characteristic and by eliminating redundant information. Drainage area was not used in this analysis because it is not a region-specific variable. Characteristics from the 333 gages included in the study were used. Characteristics were normalized to a mean of 0 so as not to influence the grouping by differences in units of measurement among the characteristics. Normalization makes the data less dependent on the kind of characteristic. Clustering also was limited to fewer than 13 groups; otherwise, groups were indistinctive or undefinable.

Cluster analysis resulted in six to eight well-defined groups. Other groupings were indistinctive or less well defined. Eight groups were considered optimal because they provided an adequate number of sites in each region for the regression analysis (fig. 3).

Initial grouping on the basis of cluster analysis delineated a large part of the Snake River Plain as one region. However, when the number of possible groups was increased to 10, 11, or 12, sites on the plain showed more diversity between one another and differences were greater between sites located on the eastern and western sides of the plain. These differences also were apparent in the regionalization study by Thomas and others (1994) and somewhat apparent in the study by Thomas and others (1973), who divided the eastern and western Snake River Plain into separate regions. In keeping with the numbering system of Hortness and Berenbrock (2001), region 7 was divided accordingly and redesignated as regions 7a and 7b, which correspond with the western Snake River Plain and eastern Snake River Plain, respectively (fig. 3).

A part of the area commonly referred to as the
eastern Snake River Plain (region 0) was excluded 1
from the regionalization for several reasons: (1) Most of the streams in this region either are regulated or are significantly affected by irrigation diversions, (2) several springs with extremely large discharges add significant flow to streams in the region, and (3) the lithology of the area consists mainly of layered basalts that exhibit extremely high rates of infiltration. The effects of these features on the hydrology of the area cannot be characterized by a regional regression approach.

METHODS FOR ESTIMATING PEAK FLOWS FOR GAGED SITES

Two methods were developed to estimate peak flows at various recurrence intervals for gaged sites

Table 3. Description of selected basin and climatic characteristics used in the final predictive equations

[Multiply meter by 3.281 to obtain foot; multiply kilometer (km) by 0.6214 to obtain mile]

Characteristic	Description
Drainage area (DA)	Drainage area of the basin that contributes surface runoff, in square miles; estimated using Arc/Info Grid with 30-meter-resolution digital-elevation models (DEMs)
Mean basin elevation (E)	Mean elevation of the basin, in feet above sea level; estimated using Arc/Info Grid and averaging elevations using 30-meter-resolution DEMs
Forested area (F)	Area of the basin containing forest, in percent of total drainage area; estimated using Arc/Info Grid with a 37-meter-resolution land-cover grid
Mean annual precipitation (P)	Mean annual precipitation over the entire drainage area, in inches; estimated using Arc/Info Grid with a combination of 500-meter (within Idaho) and 4-km (outside of Idaho) resolution precipitation grids
Basin slope (BS)	Average slope of the basin, in percent; estimated using the “average maximum technique” in Arc/Info Grid with 30-meter-resolution DEMs
North-facing slopes greater than 30 percent (NF30)	Area of north-facing slopes with slopes greater than 30 percent, in percent of drainage area; estimated using the “average maximum technique” in Arc/Info Grid with 30-meter-resolution DEMs
Slopes greater than 30 percent (S30)	Area with slopes greater than 30 percent, in percent of drainage area; estimated using the “average maximum technique” in Arc/Info Grid with 30-meter-resolution DEMs

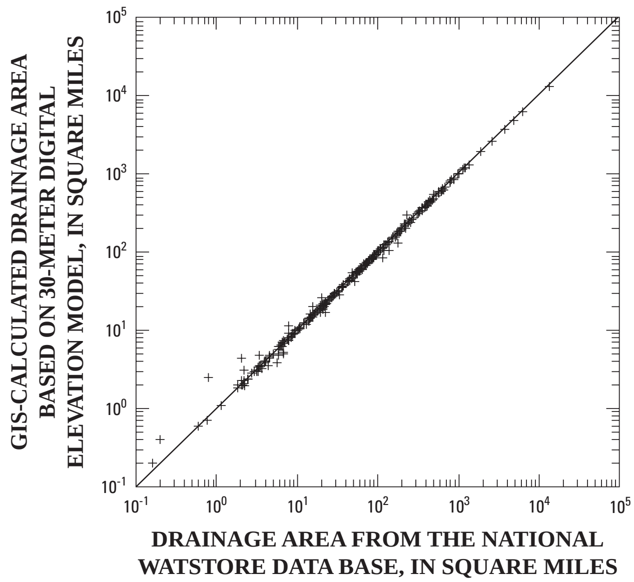


Figure 2. Comparison between GIS-calculated drainage area and national WATSTORE drainage area for streamflow-gaging stations in Idaho and bordering States. (GIS, geographic information system; WATSTORE, Water Data Storage and Retrieval System)

or for an ungaged site near a gaged site on the same stream. These methods and their limitations are explained in this section, and step-by-step procedures and examples for using the methods are given in the section entitled "Application of Methods." If the site in question does not fit in either category, then the method developed for estimating peak flows for ungaged sites on unregulated and undiverted streams, which is explained in the section entitled "Methods for Estimating Peak Flows for Ungaged Sites," can be used.

Gaged Sites

Flood-frequency estimates for a given stream site typically are presented as a set of exceedance probabilities or, alternatively, recurrence intervals, along with the associated peak flows. Exceedance probability is defined as the probability of exceeding a specified peak flow in a 1-year period and is expressed as decimal fractions less than 1.0 or as percentages less than 100. A peak flow with an exceedance probability of 0.10 has a 10-percent chance of being exceeded in any given year. Recurrence interval is defined as the number of years, on average, during which the specified peak flow is expected to be exceeded one time and is expressed as number of years. A peak flow with a 10-year recurrence interval is one that, on average, will be exceeded once every 10 years. Recurrence interval and exceedance probability are mathematical inverses of one another; thus, a discharge with an exceedance probability of 0.10 has a recurrence interval of 10 years ($\frac{1}{0.10} = 10$). Conversely, a peak flow with a recurrence interval of 10 years has an exceedance probability of one-tenth or 0.10 ($\frac{1}{10} = 0.10$). It is important to remember that recurrence intervals, regardless of length, always refer to the average number of occurrences over a long period of time; for example, a 10-year peak flow is one that might occur about 10 times in a 100-year period, rather than exactly once every 10 years.

Flood-frequency estimates for gaged sites are calculated by fitting some known statistical distribution to the series of annual peak flows. For this study, estimates of peak-flow frequency were calculated by fitting a log-Pearson Type III distribution to the logarithms (base 10) of the annual peak flows, following the guidelines and using the calculation methods described in Bulletin 17B of the Interagency Advisory Committee on Water Data (1982). The equation for fitting the log-Pearson Type III distribution to an observed series of annual peak flows is as follows:

$$\log Q_T = \overline{X} + KS, \qquad (1)$$

where

Q_T *is* T-year peak flow, in cubic feet per second;

$\overline{X}$ *is* mean of the log-transformed annual peak flow;

K *is* frequency factor dependent on the recurrence interval and the skew coefficient of the log-transformed annual peak flow; and

S *is* standard deviation of the log-transformed annual peak flow.

Values of K for a wide range of recurrence intervals and skew coefficients are published in Appendix 3 of Bulletin 17B (Interagency Advisory Committee on Water Data, 1982).

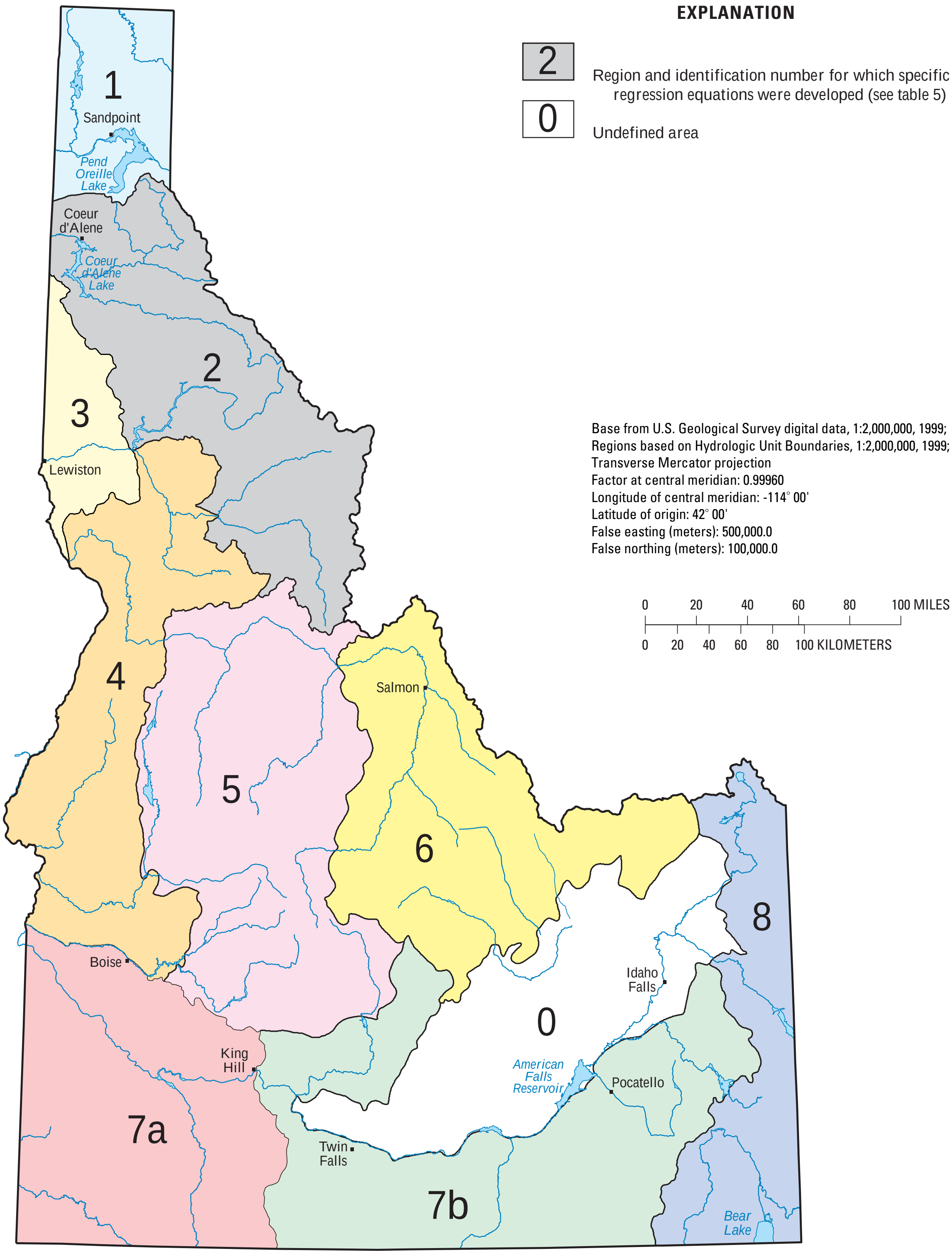


Figure 3. Locations of regions in Idaho used in regional regression analysis.

A skew coefficient measures the symmetry of the distribution of a set of peak flows about the median of the distribution. A peak-flow distribution with a mean equal to the median is said to have zero skew. A positively skewed distribution has a mean that exceeds the median. One or more extremely large peak flows within a record of significantly smaller peak flows often result in a positive skew coefficient. A negatively skewed distribution has a mean that is less than the median. Several very small peak flows within a record of generally larger peak flows often result in a negative skew.

The calculated skew coefficient for any peak-flow record is very sensitive to extreme peak flows. Therefore, the skew coefficient for a gage with a short period of record might not provide an accurate estimate of the population skew. Thus, a flood-frequency estimate made using equation (1) might not be reliable. A more accurate estimate of skew coefficient can be obtained by weighting the sample (individual gage) skew coefficient with a regional skew coefficient (Interagency Advisory Committee on Water Data, 1982).

A regional skew coefficient is based on regional trends in the skew coefficients calculated from long-term gages. A nationwide regional skew study was conducted by the Interagency Advisory Committee on Water Data (1982), and skew coefficients from long-term gages throughout the Nation were calculated and used to produce a map showing equal lines of regional skew. Kjelstrom and Moffatt (1981) produced regional skew maps of Idaho for rainfall, snowmelt, and rainfall-snowmelt events. Their regional skew map for snowmelt matched the nationwide regional skew map. Therefore, their maps were used to calculate the regional skew for gages in this study. To calculate the weighted skew, the mean square error of regional skew and sample skew are needed. The mean square errors of regional skew from the 1981 maps were 0.18 for rainfall events, 0.15 for snowmelt events, and 0.16 for rainfall-snowmelt events (L.C. Kjelstrom, U.S. Geological Survey, written commun., 1999). Flood-frequency estimates for all gages used in this study were calculated using a weighted skew.

Fitting the log-Pearson Type III distribution to a long series of annual peak flows is fairly straightforward. Often, however, a series of peak flows can include extremely small or large peak flows that depart significantly from the trend in the data (low or high outliers). The peak-flow record also can include peak flows that occurred outside of the period of regularly collected (systematic) record. Such peak flows, known as historical peaks, are often the maximum peak flows known to have occurred. The interpretation of outliers and historical peak information in the fitting process can greatly affect the final flood-frequency estimate. Bulletin 17B (Interagency Advisory Committee on Water Data, 1982) provides guidelines for detecting and interpreting these outliers and provides calculation methods for making appropriate corrections to the distribution to account for their presence.

Bulletin 17B (Interagency Advisory Committee on Water Data, 1982) guidelines were followed for determining flood-frequency estimates for the 333 gages that formed the database (table 5). The period of known peak flows and the number of years of known peak flows also are listed in table 5. For gages not listed in table 5, flood-frequency estimates can be calculated using procedures described in this section and in Bulletin 17B (Interagency Advisory Committee on Water Data, 1982).

Ungaged Sites Near Gaged Sites on the Same Stream

Flood frequencies for ungaged sites near gaged sites on the same stream can be estimated using a ratio of drainage area for the ungaged site to drainage area for the gaged site as shown in the following equation (the drainage-area ratio DA_u/DA_g should be approximately between 0.5 and 1.5):

$$Q_u = \left(\frac{DA_u}{DA_g}\right)^a Q_g \,, \tag{2}$$

where

Q_u *is* peak flow for the selected flood frequency for the ungaged site,

DA_u *is* drainage area for the ungaged site,

DA_g *is* drainage area for the gaged site,

a *is* exponent for drainage area for each hydrologic region (table 6), and

Q_g *is* peak flow for the selected flood frequency for the gaged site.

The exponent, *a*, was determined by regressing the logarithms of the T-year flood (T = 2, 5, 10, 25, 50, 100, 200, and 500) against the logarithm of DA for each region and averaging the regression coefficients for the eight recurrence intervals. The values of the exponent for each region are shown in table 6.

If an ungaged site is between two gaged sites, the flood-frequency data for the ungaged site can be estimated by interpolating between values for the two gages using the following equation:

$$Q_u = \left[\frac{Q_{g_1}(DA_{g_2} - DA_u) + Q_{g_2}(DA_u - DA_{g_1})}{(DA_{g_2} - DA_{g_1})} \right], \qquad (3)$$

where

Q_u *is* peak flow for the selected frequency for the ungaged site between gaged sites 1 and 2,

Q_{g_1} *is* peak flow for the selected flood frequency for the upstream gage,

DA_{g_2} *is* drainage area for the downstream gage,

DA_u *is* drainage area for the ungaged site,

Q_{g_2} *is* peak flow for the selected flood frequency for the downstream gage, and

DA_{g_1} *is* drainage area for the upstream gage.

Table 6. Value of exponent, *a*, for regions in Idaho used in regional regression analysis

Region	Exponent *a*	Region	Exponent *a*
1	0.65	6	0.80
2	0.88	7a	0.77
3	0.84	7b	0.65
4	0.85	8	0.90
5	0.94		

METHODS FOR ESTIMATING PEAK FLOWS FOR UNGAGED SITES

Two regional regression methods were used to develop equations for estimating peak flows for ungaged sites on unregulated and undiverted streams in Idaho. The first method used generalized least-squares (GLS) regression to define a set of predictive equations that related peak flow at the 2-, 5-, 10-, 25-, 50-, 100-, 200-, and 500-year recurrence intervals to selected basin characteristics for each hydrologic region in Idaho. The second method, the region-of-influence (ROI) method (Tasker and Slade, 1994), was used to develop unique regression equations for each ungaged site on the basis of an optimal set of gaged sites with values of basin and climatic characteristics that were similar to those of the ungaged site. GLS regression also was used to develop the predictive equations for the ROI method. Neither method was reliable for the eastern Snake River Plain (region 0) (see section entitled “Determination of Regions” for more explanation).

Regional Regression Method

For both regression methods, all peak-flow data and basin and climatic characteristics were transformed to base-10 logarithms. Before transformation of the data, a value of 1 was added to data that were a percentage measure (for example, forest cover). This would ensure that 0 values, which cannot be transformed, would not result. Also, mean basin elevation (E) values were divided by 1,000 before transformation to allow for more convenient coefficients in the final equations. Transformation was performed to obtain linear relations between explanatory variables (basin and climatic characteristics) and response variables (T-year peak flows) and to achieve equal variance about the regression line.

Ordinary least-squares (OLS) linear regression was used initially to determine the best combination of transformed explanatory variables to use in the GLS regression equation for each region. Initially, 18 explanatory variables were considered. The best combination of the explanatory variables was based on minimizing Mallow’s Cp, the PRESS statistic, the standard error of the estimate (SEE) (Helsel and Hirsch, 1992), and passing of diagnostic checks to test for outliers, high-influence values, and multicollinearity between explanatory variables. For example, the best combination of explanatory variables for region 1 was drainage area, mean basin elevation, and percent forest cover. These three variables were highly significant (the *p*-values from the T-statistics were less than 0.0001) in the OLS regression.

OLS regression is an appropriate and efficient regression analysis to use when the peak flows for gaged sites (response variables) are independent of each other (no correlation exists between pairs of sites) and when the record lengths and variability of the peak flows for different gaged sites are approximately equal. Records of peak flow from gages on the same stream, on different streams within the same basins, or even on streams in adjacent basins can be highly correlated, however, because the peak flows might have resulted from the same rainfall-snowmelt events. Peak-flow record lengths for sites used in this study ranged from 10 to 91 years and, thus, cannot be considered equal for all sites. Peak flows for gaged sites ranged from 4 to 149,000 ft^3/s and cannot be considered equal for all sites. For these reasons, OLS regression was used only as an exploratory technique.

GLS regression, as described by Stedinger and Tasker (1985), is a regression technique that takes into account the correlation between sites, as well as the differences in record lengths and variability of peak flows for gaged sites. These factors are accounted for in GLS regression by assigning different weights to each observation of the peak flow on the basis of its contribution to the total variance of the sample flow statistics.

GLS regression was used to calculate the final coefficients and measures of accuracy for the regional regression equations for each region. The computer program GLSNET (Tasker and Stedinger, 1989) was used to develop the regional regression equations and error results. To account for the effects of cross correlation, the GLS regression used a “best-fit” mathematical relation between sample cross-correlation coefficients and distance between sites for site pairs with long periods (at least 30 years) of concurrent record. This best-fit relation then was used to populate a cross-correlation matrix for the sites contained in each region. The matrix was used to give less weight to sites whose concurrent peak flows were correlated with those for other sites. The variability of peak flows for each site was measured by the standard deviation of the population of all peak flows for that site. The standard deviation of the population of peak flows for each site was calculated from a regression of the sample standard deviations against drainage area. These regression estimates of the standard deviations were used to assign weights to peak flows. Finally, the length of record at each site was used as a direct measure of the relative reliability of the T-year flow estimates calculated from those records. Less weight was given to sites with shorter periods of record.

Region-of-Influence Method

The ROI method (Tasker and Slade, 1994) was used to estimate T-year peak flows for ungaged sites from regression relations between T-year peak flows and basin and climatic characteristics for a unique subset of gaged sites. This unique subset of gaged sites, first suggested by Acreman and Wiltshire (1987), was described by Burn (1990a, 1990b) as the region of influence for the ungaged site, hence the name of the method. The unique subset of gaged sites is defined as the number, N, of gaged sites nearest to the ungaged site (Pope and Tasker, 1999), where nearest is determined from the Euclidean distance metric:

$$d_{ij} = \left[\sum_{k=1}^{p} \frac{(x_{ik} - x_{jk})^2}{sd\,(x_k)} \right]^{\frac{1}{2}}, \qquad (4)$$

where

d_{ij} *is* distance between two sites i and j in terms of basin and climatic characteristics,

p *is* number of basin and climatic characteristics used to calculate d_{ij},

x_{ik} *is* k^{th} basin and climatic characteristics at site i,

x_{jk} *is* k^{th} basin and climatic characteristics at site j,

x_k *is* k^{th} basin and climatic characteristic, and

$sd\,(x_k)$ *is* sample standard deviation for x_k.

The distance metric measures the multidimensional distance between two sites defined in terms of the basin and climatic characteristics.

This distance metric is directly analogous to the more familiar equation for distance, $D = [(x_2 - x_1)^2 + (y_2 - y_1)^2]^{\frac{1}{2}}$ in a two-dimensional rectangular coordinate system. The only difference between this equation and equation (4) is the use of sample standard deviation to standardize the different basin and climatic characteristics (remove the effects of disproportional units) and the notational difference of using an additional subscript (k) rather than changing variable symbols (x, y).

The ROI for an ungaged site is determined using equation (4) by first computing the distances (d_{ij}) between the ungaged site and all the gaged sites. The distances are ranked and the N sites with the smallest d_{ij} compose the ROI for that ungaged site. This technique is analogous to separating an area into similar physiographic, climatic, and (or) hydrologic regions (regionalization) as was done for the previous regression method. Once the ROI is determined, GLS regression techniques are used to develop the unique predictive relations between T-year peak flows and basin characteristics for the ungaged site.

The basin and climatic characteristics used to define an ROI need not be the same explanatory variables used in the subsequent GLS regression. For example, in a flood-frequency analysis in North Carolina for which the ROI method was used, the set of characteristics used as explanatory variables was a subset of the characteristics used to define d_{ij} (Pope and Tasker, 1999).

The number of gaged sites and basin characteristics used to define the ROI and perform the GLS regression were selected by trial and error, using a calculated root-mean-squared error (RMSE) as the criterion for selection. RMSE was calculated by removing one site at a time from the database and using the remaining sites to define a new regression equation for the site and to calculate an estimate of the peak flow. RMSE was calculated as the square root of the arithmetic mean of the differences between the estimated and calculated values of peak flow for each site. Then RMSEs were compared with results from the regional regression method for each region.

RESULTS OF ESTIMATING PEAK FLOWS FOR UNGAGED SITES

Two methods were developed to estimate peak flows at various recurrence intervals for ungaged sites on unregulated and undiverted streams in Idaho. These methods are explained in a previous section entitled "Methods for Estimating Peak Flows for Ungaged Sites," and step-by-step procedures and examples of using the methods are given in the section entitled "Application of Methods."

Regional Regression Analysis

GLS regression equations for recurrence intervals of 2, 5, 10, 25, 50, 100, 200, and 500 years were developed for all regions (table 7). Drainage area (DA) was included in regression equations for all regions; mean basin elevation (E), for five of the regions; and mean annual precipitation (P), for two of the regions. At least one of the following variables—forest cover (F), north-facing slopes greater than 30 percent (NF30), basin slope (BS), and slopes greater than 30 percent (S30)—was included in regression equations for three regions. No equation included more than three explanatory variables. Region 7b was the only region that included only one explanatory variable (DA). Three of the explanatory variables—NF30, BS, and S30—have not been used previously in regional regression equations for estimation of flood frequency in Idaho.

The standard error of the regression model and the average standard error of prediction also are listed in table 7. The standard error of the regression model is a measure of how well the regression model fits the data used to construct it. This error term is also often termed the standard error of estimate. The average standard error of prediction is the sum of two components—model error plus sampling error—which results from estimating model parameters from samples of the population. The model error is a characteristic of the model and is a constant for all sites. The sampling error for a given site, however, depends on the values of the explanatory variables used to develop the peak-flow estimate at that site. The error of prediction, therefore, varies from site to site. The standard error of prediction provides a better overall measure of a model's predictive reliability than does the model error. A more rigorous mathematical description of these errors and how to convert them from logarithms (base-10 units) to percent errors are given in a report by Pope and Tasker (1999, p. 12).

Standard errors of the model were different for each region and for each recurrence interval (table 7). The largest and smallest average standard errors of the model were +131 percent and -56.6 percent, respectively. The range of model standard errors for all recurrence intervals was narrowest for region 5. The range

Table 7. Predictive regression equations and their accuracy in estimating peak flows for ungaged sites on unregulated and undiverted streams in Idaho

[Q, peak flow, in cubic feet per second; DA, drainage area, in square miles; E, mean basin elevation, in feet; F, percentage of forest cover in the basin; P, mean annual precipitation, in inches; NF30, percentage of north-facing slopes greater than 30 percent; S30, percentage of slopes greater than 30 percent; BS, average basin slope, in percent]

Peak-flow regression equations for given recurrence interval (2 to 500 years)	Standard error of model (percent)	Standard error of prediction (percent)
Region 1 (Equations based on data from 21 gaging stations)		
$Q_2 = 2.52\ DA^{0.775}\ (E/1{,}000)^{3.32}\ (F+1)^{-0.504}$	+69.0 to -40.8	+78.4 to -43.9
$Q_5 = 23.0\ DA^{0.720}\ (E/1{,}000)^{3.36}\ (F+1)^{-0.885}$	+53.3 to -34.8	+61.1 to -37.9
$Q_{10} = 81.5\ DA^{0.687}\ (E/1{,}000)^{3.40}\ (F+1)^{-1.10}$	+49.0 to -32.9	+56.8 to -36.2
$Q_{25} = 339\ DA^{0.649}\ (E/1{,}000)^{3.44}\ (F+1)^{-1.36}$	+48.5 to -32.6	+57.1 to -36.3
$Q_{50} = 876\ DA^{0.623}\ (E/1{,}000)^{3.47}\ (F+1)^{-1.53}$	+50.6 to -33.6	+60.1 to -37.6
$Q_{100} = 2{,}080\ DA^{0.597}\ (E/1{,}000)^{3.49}\ (F+1)^{-1.68}$	+54.2 to -35.2	+64.8 to -39.3
$Q_{200} = 4{,}660\ DA^{0.572}\ (E/1{,}000)^{3.52}\ (F+1)^{-1.82}$	+58.9 to -37.1	+70.8 to -41.4
$Q_{500} = 12{,}600\ DA^{0.540}\ (E/1{,}000)^{3.56}\ (F+1)^{-2.00}$	+66.5 to -39.9	+80.1 to -44.5
Region 2 (Equations based on data from 44 gaging stations)		
$Q_2 = 0.742\ DA^{0.897}\ P^{0.935}$	+60.2 to -37.6	+64.2 to -39.1
$Q_5 = 1.50\ DA^{0.888}\ (E/1{,}000)^{-0.330}\ P^{0.992}$	+60.1 to -37.5	+64.3 to -39.1
$Q_{10} = 2.17\ DA^{0.884}\ (E/1{,}000)^{-0.538}\ P^{1.04}$	+61.4 to -38.0	+65.8 to -39.7
$Q_{25} = 3.24\ DA^{0.879}\ (E/1{,}000)^{-0.788}\ P^{1.10}$	+63.9 to -39.0	+68.7 to -40.7
$Q_{50} = 4.22\ DA^{0.876}\ (E/1{,}000)^{-0.962}\ P^{1.14}$	+66.1 to -39.8	+71.4 to -41.6
$Q_{100} = 5.39\ DA^{0.874}\ (E/1{,}000)^{-1.13}\ P^{1.18}$	+68.5 to -40.6	+74.1 to -42.6
$Q_{200} = 6.75\ DA^{0.872}\ (E/1{,}000)^{-1.29}\ P^{1.21}$	+71.1 to -41.5	+77.1 to -43.5
$Q_{500} = 8.90\ DA^{0.869}\ (E/1{,}000)^{-1.49}\ P^{1.26}$	+74.7 to -42.8	+81.3 to -44.8
Region 3 (Equations based on data from 26 gaging stations)		
$Q_2 = 26.3\ DA^{0.864}\ (E/1{,}000)^{-0.502}$	+78.3 to -43.9	+86.4 to -46.4
$Q_5 = 127\ DA^{0.842}\ (E/1{,}000)^{-1.31}$	+52.1 to -34.3	+58.6 to -36.9
$Q_{10} = 265\ DA^{0.837}\ (E/1{,}000)^{-1.68}$	+45.2 to -31.1	+51.8 to -34.1
$Q_{25} = 504\ DA^{0.833}\ (E/1{,}000)^{-1.95}$	+43.0 to -30.1	+50.3 to -33.5
$Q_{50} = 719\ DA^{0.832}\ (E/1{,}000)^{-2.08}$	+43.9 to -30.5	+51.9 to -34.2
$Q_{100} = 965\ DA^{0.831}\ (E/1{,}000)^{-2.18}$	+46.3 to -31.6	+55.1 to -35.5
$Q_{200} = 1{,}240\ DA^{0.831}\ (E/1{,}000)^{-2.26}$	+49.7 to -33.2	+59.4 to -37.3
$Q_{500} = 1{,}660\ DA^{0.832}\ (E/1{,}000)^{-2.35}$	+55.4 to -35.6	+66.2 to -39.8

Table 7. Predictive regression equations and their accuracy in estimating peak flows for ungaged sites on unregulated and undiverted streams in Idaho—Continued

Peak-flow regression equations for given recurrence interval (2 to 500 years)	Standard error of model (percent)	Standard error of prediction (percent)
Region 4 (Equations based on data from 60 gaging stations)		
$Q_2 = 16.3\ DA^{0.893}\ (E/1{,}000)^{-0.121}$	+80.5 to -44.6	+83.5 to -45.5
$Q_5 = 46.3\ DA^{0.874}\ (E/1{,}000)^{-0.459}$	+66.6 to -40.0	+69.1 to -40.9
$Q_{10} = 79.2\ DA^{0.863}\ (E/1{,}000)^{-0.628}$	+61.2 to -37.9	+63.6 to -38.9
$Q_{25} = 139\ DA^{0.852}\ (E/1{,}000)^{-0.801}$	+56.9 to -36.3	+59.5 to -37.3
$Q_{50} = 198\ DA^{0.844}\ (E/1{,}000)^{-0.910}$	+55.2 to -35.6	+57.7 to -36.6
$Q_{100} = 273\ DA^{0.837}\ (E/1{,}000)^{-1.01}$	+54.2 to -35.1	+56.9 to -36.3
$Q_{200} = 365\ DA^{0.831}\ (E/1{,}000)^{-1.10}$	+53.8 to -35.0	+56.6 to -36.1
$Q_{500} = 521\ DA^{0.822}\ (E/1{,}000)^{-1.20}$	+53.9 to -35.0	+56.9 to -36.3
Region 5 (Equations based on data from 46 gaging stations)		
$Q_2 = 0.0297\ DA^{0.995}\ P^{2.20}\ (NF30+1)^{-0.664}$	+43.6 to -30.4	+46.7 to -31.8
$Q_5 = 0.0992\ DA^{0.970}\ P^{1.92}\ (NF30+1)^{-0.602}$	+41.7 to -29.4	+44.8 to -30.9
$Q_{10} = 0.178\ DA^{0.957}\ P^{1.79}\ (NF30+1)^{-0.571}$	+41.7 to -29.4	+45.0 to -31.1
$Q_{25} = 0.319\ DA^{0.943}\ P^{1.66}\ (NF30+1)^{-0.538}$	+42.3 to -29.7	+46.0 to -31.5
$Q_{50} = 0.456\ DA^{0.934}\ P^{1.58}\ (NF30+1)^{-0.517}$	+43.1 to -30.1	+47.1 to -32.0
$Q_{100} = 0.620\ DA^{0.926}\ P^{1.52}\ (NF30+1)^{-0.499}$	+44.1 to -30.6	+48.4 to -32.6
$Q_{200} = 0.813\ DA^{0.919}\ P^{1.46}\ (NF30+1)^{-0.483}$	+45.3 to -31.2	+49.8 to -33.2
$Q_{500} = 1.12\ DA^{0.911}\ P^{1.39}\ (NF30+1)^{-0.464}$	+46.9 to -31.9	+51.9 to -34.2
Region 6 (Equations based on data from 31 gaging stations)		
$Q_2 = 0.000258\ DA^{0.893}\ P^{3.15}$	+71.2 to -41.6	+76.5 to -43.4
$Q_5 = 0.00223\ DA^{0.846}\ P^{2.68}$	+63.9 to -39.0	+68.8 to -40.8
$Q_{10} = 0.00632\ DA^{0.824}\ P^{2.45}$	+62.9 to -38.6	+67.9 to -40.4
$Q_{25} = 0.0181\ DA^{0.801}\ P^{2.22}$	+63.4 to -38.8	+68.8 to -40.8
$Q_{50} = 0.0346\ DA^{0.787}\ P^{2.08}$	+64.4 to -39.2	+70.2 to -41.2
$Q_{100} = 0.0607\ DA^{0.775}\ P^{1.96}$	+65.8 to -39.7	+71.8 to -41.8
$Q_{200} = 0.100\ DA^{0.763}\ P^{1.85}$	+67.3 to -40.2	+73.8 to -42.4
$Q_{500} = 0.180\ DA^{0.750}\ P^{1.73}$	+69.6 to -41.0	+76.5 to -43.3

Table 7. Predictive regression equations and their accuracy in estimating peak flows for ungaged sites on unregulated and undiverted streams in Idaho—Continued

Peak-flow regression equations for given recurrence interval (2 to 500 years)	Standard error of model (percent)	Standard error of prediction (percent)
Region 7a (Equations based on data from 28 gaging stations)		
$Q_2 = 2.28\ DA^{0.759}\ (E/1{,}000)^{0.769}$	+74.8 to -42.8	+82.3 to -45.2
$Q_5 = 27.3\ DA^{0.762}\ (E/1{,}000)^{-0.211}$	+59.9 to -37.5	+66.6 to -40.0
$Q_{10} = 88.4\ DA^{0.766}\ (E/1{,}000)^{-0.669}$	+55.2 to -35.6	+62.2 to -38.3
$Q_{25} = 286\ DA^{0.771}\ (E/1{,}000)^{-1.12}$	+52.9 to -34.6	+60.6 to -37.7
$Q_{50} = 592\ DA^{0.774}\ (E/1{,}000)^{-1.41}$	+53.1 to -34.7	+61.4 to -38.0
$Q_{100} = 1{,}120\ DA^{0.778}\ (E/1{,}000)^{-1.65}$	+54.4 to -35.2	+63.3 to -38.8
$Q200 = 1{,}970\ DA^{0.781}\ (E/1{,}000)^{-1.87}$	+56.5 to -36.1	+66.2 to -39.8
$Q_{500} = 3{,}860\ DA^{0.784}\ (E/1{,}000)^{-2.13}$	+60.4 to -37.6	+71.1 to -41.5
Region 7b (Equations based on data from 17 gaging stations)		
$Q_2 = 10.2\ DA^{0.611}$	+131 to -56.6	+143 to -58.8
$Q_5 = 17.1\ DA^{0.624}$	+95.3 to -48.8	+104 to -50.9
$Q_{10} = 22.4\ DA^{0.633}$	+79.7 to -44.4	+86.9 to -46.5
$Q_{25} = 29.9\ DA^{0.644}$	+66.9 to -40.1	+73.5 to -42.3
$Q_{50} = 35.7\ DA^{0.653}$	+61.7 to -38.1	+68.0 to -40.5
$Q_{100} = 41.6\ DA^{0.662}$	+59.5 to -37.3	+66.1 to -39.8
$Q_{200} = 47.5\ DA^{0.672}$	+60.0 to -37.5	+66.9 to -40.1
$Q_{500} = 55.5\ DA^{0.686}$	+64.1 to -39.1	+71.8 to -41.8
Region 8 (Equations based on data from 60 gaging stations)		
$Q_2 = 1.49\ DA^{0.942}\ BS^{1.15}\ (S30+1)^{-0.563}$	+82.9 to -45.3	+86.9 to -46.5
$Q_5 = 1.93\ DA^{0.915}\ BS^{1.53}\ (S30+1)^{-0.862}$	+76.1 to -43.2	+79.8 to -44.4
$Q_{10} = 2.10\ DA^{0.903}\ BS^{1.75}\ (S30+1)^{-1.03}$	+74.7 to -42.7	+78.3 to -43.9
$Q_{25} = 2.22\ DA^{0.892}\ BS^{1.99}\ (S30+1)^{-1.21}$	+74.5 to -42.7	+78.2 to -43.9
$Q_{50} = 2.26\ DA^{0.886}\ BS^{2.15}\ (S30+1)^{-1.33}$	+75.0 to -42.9	+78.9 to -44.1
$Q_{100} = 2.27\ DA^{0.882}\ BS^{2.31}\ (S30+1)^{-1.44}$	+75.9 to -43.1	+79.9 to -44.4
$Q_{200} = 2.25\ DA^{0.878}\ BS^{2.45}\ (S30+1)^{-1.54}$	+77.0 to -43.5	+81.2 to -44.8
$Q_{500} = 2.22\ DA^{0.874}\ BS^{2.62}\ (S30+1)^{-1.67}$	+78.8 to -44.1	+83.2 to -45.4

of model standard errors for 2-, 5-, and 10-year recurrence intervals was widest for region 7b and, for 25- through 500-year recurrence intervals, was widest for region 8. The largest and smallest average standard errors of prediction ranged from +143 percent to -58.8 percent (table 7). The range of average standard errors of prediction was narrowest for region 5. Model and prediction errors generally were closer to 0 for the middle recurrence intervals (5, 10, 25, and 50 years) and farther from 0 for the lower and upper recurrence intervals (2, 100, 200, and 500 years). Basically, results of average standard errors of prediction were similar to results of model standard errors.

Average standard errors from these regression equations were compared with the average standard errors from previous regression studies in Idaho (table 1). The average standard errors of prediction in table 7 were converted to a single average standard error of prediction, in percent, by procedures described by Aitchison and Brown (1957). This single value was required for comparison with a single value from previous studies. For this study, average standard errors of prediction for Q_{100} in all regions ranged from a minimum of 41 percent for region 5 to a maximum of 72 percent for region 8. Standard errors generally were smallest for region 5 and largest for region 8. Standard errors from this study were consistently smaller and the ranges narrower than those from previous studies (table 1). No real comparison can be made with Kjelstrom and Moffatt's study (1981) because no distinction was made in errors between frequencies. Only the maximum error of 62 percent from the study of Thomas and others (1973) was smaller than the maximum error from this study (77 percent).

Region-of-Influence Analysis

Initially, basin and climatic characteristics from the final regional regression equations (table 7) were used to define an ROI and explanatory variables. The entire database, which consisted of 333 gaged sites, was used to determine the unique subset of gaged sites. Combinations of the seven variables were tested to determine the number (N) of gaged sites and the number and identity of the basin and climatic characteristics of d_{ij} and explanatory variables in the ROI. Each set of variables was tested using values of N starting at 20 and increasing by 5 until 100 sites were used. Initial testing indicated that RMSEs increased significantly when DA was used singly or in combination with other variables for d_{ij}. As a result, DA was used only as an explanatory variable in subsequent testing.

The best combination of variables to define the ROI was forest cover and slopes greater than 30 percent, and the optimal value for N was 40. The best combination of explanatory variables defined by the GLS regression part of the analysis was drainage area, mean basin elevation, mean annual precipitation, and forest cover.

The average RMSE was calculated for the ROI method (table 8) and ranged from 55.5 percent for a 5-year recurrence interval to 72.4 percent for a 500-year recurrence interval. Also, the average RMSE was calculated for the regional regression equations (table 7) for each region and recurrence interval and is shown in table 8. On the basis of RMSE comparisons (table 8) between the ROI method and the regional regression equations, the regional regression equations produced better overall results (smaller RMSEs) for regions 1 through 7a. For parts of regions 7b and 8, the ROI method produced slightly better results than did the regional regression equations only in the lower frequency intervals. For most regions, the differences between the two methods were greater than 10 percent and, for region 5, were greater than 20 percent.

In an effort to obtain smaller RMSE values than the regional regression equations produced, regions were combined to form several sets of larger regions. In other ROI studies (Pope and Tasker, 1990; Tasker and Slade, 1994; Hodge and Tasker, 1995), the ROI method was applied to several large regions (containing at least 100 gaged sites) within the respective State. In this study, regions 1, 2, and 3 were combined to form the first set; regions 4 and 5 were combined to form the second set; and regions 6, 7a, 7b, and 8 were combined to form the third set. Then the ROI method was applied to each of the three combined regions. Combining regions did not result in smaller RMSE values than when all 333 gaged sites in the database were used. Regions were subsequently recombined and retested but, again, no smaller RMSE values resulted than when all gages were used. Therefore, the ROI method is not recommended and should not be used for determining flood-frequency estimates for ungaged sites on unregulated and undiverted streams in Idaho because the results, overall, are less accurate and the calculations are more complex than those of regional regression equations.

Table 8. Average root-mean-squared errors, in percent, for region-of-influence and regional regression methods for selected recurrence intervals

Recurrence interval	Average root-mean-squared error, in percent									
	Region-of-influence method	Regional regression method								
		Region 1	Region 2	Region 3	Region 4	Region 5	Region 6	Region 7a	Region 7b	Region 8
2	60.2	63.1	52.8	68.8	66.8	39.8	61.7	65.9	109	69.2
5	55.5	50.5	52.9	48.7	56.4	38.3	56.2	54.6	81.2	64.1
10	55.9	47.4	53.9	43.6	52.4	38.5	55.5	51.3	69.2	63.0
25	58.3	47.5	56.2	42.5	49.4	39.2	56.3	50.2	59.5	62.9
50	60.9	49.8	58.0	43.7	48.1	40.0	57.2	50.7	55.6	63.4
100	64.0	53.3	60.0	46.1	47.4	41.1	58.4	52.2	54.2	64.2
200	67.4	57.6	62.2	49.3	47.2	42.1	59.7	54.3	54.8	65.1
500	72.4	64.3	65.2	54.3	47.4	43.7	61.8	57.8	58.3	66.5

LIMITATIONS OF REGIONAL REGRESSION EQUATIONS

The average standard errors of prediction given in table 7 represent the general measure of how well the regional regression equations will estimate peak flows when they are applied to ungaged sites. The accuracy of the equations will be reduced if the values of explanatory variables are outside the range of the values used to develop the equations. The magnitude of this reduction in accuracy is unknown. Standard errors of prediction vary from site to site, depending on the values of the explanatory variables for each site. The standard errors of prediction will be smaller for sites where values of the explanatory variables are near the mean of their range. If the value of an explanatory variable used in the regression equations is near its extreme (maximum or minimum, table 4), the equations might result in unreliable and erroneous estimates. For example, figure 4 shows a “cloud of common values” for the two explanatory variables used in regression equations for region 3. If the maximum value for drainage area and the minimum value for mean basin elevation were used, this combination would plot outside the cloud of common values and, thus, the equations might result in unreliable estimates.

Generating basin characteristic values using datasets or algorithms other than those described in this study also will result in estimates of unknown reliability. The standard errors for each equation are applicable only if the datasets presented in table 2 and methods described in table 3 are used to obtain the required basin characteristics; however, GIS programs other than Arc/Info can be used to measure and calculate the basin characteristics.

The regression equations are not applicable for streams that exhibit significant gains and (or) losses as a result of flow from springs or seepage through highly permeable streambeds. The equations also are not applicable for streams affected by irrigation diversions or large dams that regulate streamflow. The Boise River downstream from Lucky Peak Lake, the Clearwater River downstream from Dworshak Reservoir, and the entire Snake River in Idaho are examples of stream

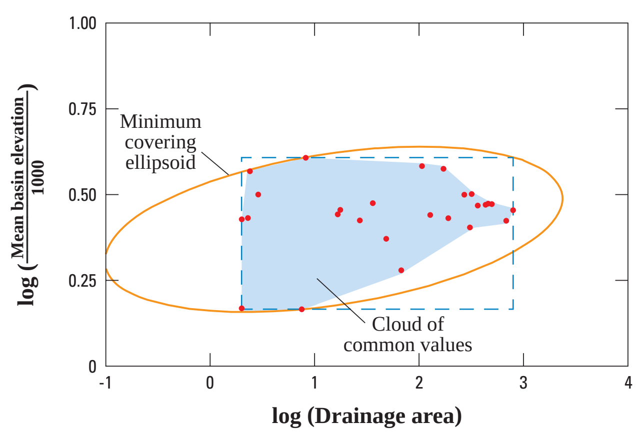


Figure 4. Joint distribution of drainage area and mean basin elevation, and minimum covering ellipsoid for gaged sites in region 3, Idaho

reaches within the study area for which the regional regression equations are not applicable.

The regional regression equations might not be reliable for sites in urbanized basins. Techniques for estimating peak flows for urban streams are presented in a report by Sauer and others (1983).

In general, the equations are more reliable (smaller standard errors of estimate) for estimating the middle peak-flow frequencies (10, 25, and 50 years) than for estimating the high peak-flow frequencies (100, 200, and 500 years) and the low peak-flow frequencies (2 and 5 years). This finding is consistent with findings in many other regional regression studies.

APPLICATION OF METHODS

For gaged sites, the magnitude of peak flows at selected recurrence intervals can be calculated using the procedures for log-Pearson Type III distribution described in the section “Methods of Estimating Peak Flows for Gaged Sites” and procedures described in Bulletin 17B (Interagency Advisory Committee on Water Data, 1982).

For ungaged sites near gaged sites on the same stream, the magnitude of peak flows can be calculated using the drainage-area ratio, also described in the section “Methods for Estimating Peak Flows for Gaged Sites,” and summarized as follows: First, the site is located on a map and the hydrologic region in which the site is located is identified. Next, the drainage boundaries of the site are delineated and the drainage area contained within those boundaries is measured using GIS software. With this information, peak flows can be calculated using equation (2), presented on p. 12. If the ungaged site lies between two gaged sites, peak flows can be calculated using equation (3), presented on p. 13.

If the ungaged site is not near a gaged site, then regional regression equations (table 7) are used to calculate peak flows. Basin and climatic characteristics used in all methods are determined using the datasets described in table 2 and methods described in table 3.

In the subsequent paragraphs, specific examples are given for calculating peak flows. The first example addresses the situation where an ungaged site is relatively near a gaged site on the same stream. The second example addresses the situation where regression equations are needed to calculate peak flows for a specific site. The third example addresses the same situation as the second example, except that the drainage area of the specified site encompasses parts of two separate regions.

Example 1

A 100-year peak-flow (Q_{100}) estimate for an ungaged site located upstream from a gaged site on the same stream in region 4 is needed. The 100-year peak flow at the gage is 7,010 ft^3/s. The drainage-area ratio method (equation 2) is used to estimate Q_{100} for the ungaged site. The drainage area (DA) is 428 mi^2 for the gaged site and 351 mi^2 for the ungaged site. DA for both sites is determined using a GIS and the datasets in table 2. The value for exponent *a* is 0.85 (table 6) for region 4. The drainage-area ratio (DA_u/DA_g) is 0.82, which is between the guideline of 0.5 and 15.

$$Q_u = \left(\frac{DA_u}{DA_g}\right)^a Q_g \, , \tag{2}$$

$$Q_{100} = \left(\frac{351}{428}\right)^{0.85} 7{,}010$$

$$Q_{100} = 5{,}920 \text{ ft}^3\text{/s}$$

Final values are rounded to three significant figures.

Example 2

A 100-year peak-flow estimate for an ungaged site in region 5 is needed. The required basin characteristics for region 5 regional regression equations were determined to be the following: DA, 480.5 mi^2; P, 28.33 in.; and NF30, 21.5 percent. Then

$$Q_{100} = 0.620 \, DA^{0.926} P^{1.52} (NF30 + 1)^{-0.499} \tag{5}$$

$$Q_{100} = 0.620 \, (480.5)^{0.926} \, 28.33^{1.52} \, (21.5 + 1)^{-0.499}$$

$$Q_{100} = 6{,}430 \text{ ft}^3\text{/s}$$

Final values are rounded to three significant figures.

On the basis of the range of the average standard errors of prediction given in table 7, about 67 percent of all estimates at this site will be between 4,340 and 9,540 ft^3/s (-32.6 to +48.4 percent). Put another way, there is about a 67-percent certainty that the “true” value of Q_T is between 4,340 and 9,540 ft^3/s. Instead of calculating these equations (table 7) manually, a computer program for the regional regression equations, presented in the section titled “Computer Program for Regional Regression Equations,” can be used. This computer program also calculates the error of prediction and the 90-percent confidence interval for individual estimates for each recurrence interval and for each region.

Example 3

A 100-year peak-flow estimate is needed for an ungaged stream in region 4 with a drainage basin encompassing parts of regions 4 and 5. The procedure is similar to that given in example 2, except the regional regression equations would be solved for each of the associated regions and the results would be averaged or apportioned according to the fraction of the contributing drainage area that is in each region (Sando, 1998). The required basin characteristics for region 4 and 5 equations were determined to be the following: DA, 853.0 mi^2; P, 35.4 in.; E, 5,125.6 ft; and NF30, 24.6 percent. The part of the drainage area in region 4 is 622.0 mi^2 and the part in region 5 is 231.0 mi^2.

Region 4 equations

$$Q_{100} = 273DA^{0.837} (E/1,000)^{-1.01} \qquad (6)$$

$$Q_{100} = 273\ (853.0)^{0.837}\ (5,125.6/1,000)^{-1.01}$$

$$Q_{100} = 14,877 \text{ ft}^3\text{/s}$$

Region 5 equations

$$Q_{100} = 0.620DA^{0.926}\ P^{1.52}\ (NF30 + 1)^{-0.499} \qquad (7)$$

$$Q_{100} = 0.620\ (853.0)^{0.926} + (35.4)^{1.52}\ (24.6)^{-0.499}$$

$$Q_{100} = 14,395 \text{ ft}^3\text{/s}$$

Area-weighted average of the 100-year peak flows

$$Q_u = Q_{g_1}\left(\frac{DA_{g_1}}{DA}\right) + Q_{g_2}\left(\frac{DA_{g_2}}{DA}\right) \qquad (8)$$

$$Q_{100} = 14,877\ (622.0/853.0) + 14,395\ (231.0/853.0)$$

$$Q_{100} = 14,700 \text{ ft}^3\text{/s}$$

Final values are rounded to three significant figures.

The computer program “Regional Regression Program” also can be used to estimate the peak-flow values in this example. The regional regression equation computer program would be executed twice, once for region 4 and once for region 5. Then the average value would be estimated by weighting according to drainage area (area-weighted average) as shown in equation 8.

COMPUTER PROGRAM FOR REGIONAL REGRESSION EQUATIONS

As part of the study described in this report, a computer program was adapted to calculate peak flows using regional regression equations (table 7). The program also calculates the associated site-specific errors of prediction for ungaged sites.

The computer software package includes an executable program file and other supporting files. The software package and instructions for downloading, installing, and executing the program are available from the Idaho District home page on the World Wide Web at URL http://idaho.usgs.gov/PDF/wri024170/program.html The executable program *idregeq.exe* will calculate peak flows for the regional regression equations (table 7). This program must be executed in a disk operating system (DOS) and the user will be prompted to input data for ungaged sites.

The regional regression equations can be calculated manually, but the program allows more convenient and efficient calculation of the errors of prediction. The errors of prediction for ungaged sites are calculated by matrix algebra using the weighted matrix $(X^T \Lambda^{-1} X)^{-1}$ obtained from GLS analysis. Further explanation for computing the error of prediction is given in a report by Hodgkins (1999), and the $(X^T \Lambda^{-1} X)^{-1}$ matrices for each recurrence interval and region are shown in table 9.

To execute the regional regression program, enter the program's name (*idregeq.exe*) in a DOS window. The program will ask for the name of an output file to save program results, an identifier (name and (or) number) of the ungaged site, the region number where the ungaged site is located, and the value for each explanatory variable used in the region's regional regression equations. Results will be displayed on the screen, and all program results will be saved in a single output file no matter how many times the program repeats. A computer session for example 2 is shown in figure 5, and the bold letters and (or) numbers are entries specified by the user and needed by the program. Figure 5 also shows calculated peak flows, site-specific standard errors of prediction (SE) and the 90-percent confidence intervals for the estimates. A confidence interval gives the level of confidence about an upper and lower limit. For example 2 (fig. 5), the 100-year peak flow is 6,430 ft^3/s, and errors of prediction range from -31.7 percent to +46.5 percent. There is a 90-percent confidence level that the predicted value for the 100-year peak flow is between 3,380 ft^3/s and 12,200 ft^3/s. If input data for explanatory variables are outside the minimum and maximum values (for example, the dashed-line box in figure 4), the program will print a warning that the specific explanatory variable is beyond the observed data.

Caution should be used when extrapolating beyond the area of the original sample data (cloud of common values) (fig. 4) when estimating peak flows from a regression model. In regression, extrapolation occurs when at least one of the predictors is outside the range of sample data. In multiple regression, it is possible for the explanatory variables to be within the minimum and maximum values and still be considered an extrapolation. For example (fig. 4), a log (Drainage area) of 2.7 and log (Mean basin elevation/1,000) of 0.21 are within the minimum and maximum values of both variables, but these values are considered extrapolations because the sample data do not contain similar combinations of variables. To define the area of interpolation or extrapolation in multiple regression, a minimum covering ellipsoid (MCE) is used because it can be expressed in mathematical form, whereas the area represented by the cloud of common values in figure 4 cannot. For two explanatory variables in a regression equation, a graph similar to figure 4 can be produced and the joint distribution can be easily seen. But for three or more explanatory variables in a regression equation, the area represented by the cloud of common values would be more difficult, if not impossible, to distinguish. To determine whether the combination of explanatory variables in an interpolation or an extrapolation, MCE calculations are included in the computer program. The program prints a warning only if the combination of explanatory variables is greater than the MCE. For more information concerning the MCE, refer to the report by Weisberg (1990). For example 2, the three explanatory variables resulted in no warning statements; thus, input data were interpolated.

SUMMARY

Accurate and reliable estimates of the magnitude and frequency of floods are critical for such activities as bridge design, flood-plain delineation and management, water-supply management, and management of water-control structures, among others. Recognizing the need for accurate estimates of flood frequency for ungaged, unregulated, and undiverted streams in Idaho, the U.S. Geological Survey, in cooperation with the Idaho Department of Transportation, Idaho Bureau of Disaster Services, and the U.S. Army Corps of Engineers, conducted a study to further define the relation between peak flows at selected recurrence intervals and selected physical and climatic characteristics. This study documents the development of methods for estimating peak flows for gaged and ungaged sites. For gaged sites, peak flows can be obtained from tables in this report or calculated by using the log-Pearson Type III distribution and following the guidelines and calculation methods described in Bulletin 17B. If the ungaged site is on a gaged stream, then peak flows can be estimated by the drainage-area ratio method that relates the drainage area for the ungaged site to the drainage area for the gaged site.

Two methods also were developed for regionalizing, or extending in space, flood-frequency estimates for gaged sites. In the first method, traditional regional regression analysis, a generalized least-squares regression was used to develop a set of predictive equations for each of the eight hydrologic regions in Idaho. In the second method, the region-of-influence method, peak-flow estimates for ungaged sites were predicted interactively on the basis of data from a subset of gaged sites with basin and climatic characteristics similar to those of the ungaged sites.

Flow records from an initial set containing more than 500 gaged sites were examined. Sites that did not

Figure 5. Input session of example 2 for the regional regression program (*idregeq.exe*). Bolded letters and numbers are input by the user.

[RI, recurrence interval in years; cfs, cubic feet per second; DA, drainage area in square miles; P, mean annual precipitation in inches; NF30, north-facing slopes greater than 30 percent in percent; C:\>, DOS command prompt]

C:\>**idregeq.exe**

```
This program computes estimates of T-year peak flows for ungaged sites in Idaho on the basis of the
REGIONAL REGRESSION METHOD.


For more information, please refer to the following report:
Berenbrock, Charles, 2002, Estimating the Magnitude of Peak Flows at Selected
Recurrence Intervals for Streams in Idaho: U.S. Geological Survey Water-
Resources Investigations Report 02-4170, 59 p.

************************************************************
* No warranty, expressed or implied, is made by the        *
* U.S. Geological Survey as to the accuracy and            *
* functioning of the program and related program material. *
************************************************************

ENTER name for output file: exp2.out

ENTER site id: Example 2

ENTER region where site is located (1,2,3,4,5,6,7a,7b,8):5

REGIONAL REGRESSION METHOD
         **** REGION 5 ****
ENTER watershed characteristics for site

Drainage area (square miles) = 480.5

Mean annual precipitation (inches)= 28.33

North-facing slopes greater than 30 percent (percent) = 21.5

Peak-flow estimates for:

Example 2
Region 5:  DA=   480.5, P=  28.33, NF30=  21.5

         PEAK FLOW      STANDARD ERRORS OF      90-PERCENT CONFIDENCE
   RI       (CFS)      PREDICTION (PERCENT)        INTERVALS (CFS)
-------------------------------------------------------------------------
    2       2740.         45.3       -31.2       1460.       5140.
    5       3730.         43.4       -30.3       2040.       6840.
   10       4410.         43.5       -30.3       2400.       8090.
   25       5200.         44.3       -30.7       2800.       9640.
   50       5740.         45.3       -31.2       3060.      10800.
  100       6430.         46.5       -31.7       3380.      12200.
  200       6950.         47.8       -32.3       3600.      13400.
  500       7650.         49.7       -33.2       3880.      15100.

 Do you want to enter another site? (y or n) n

C:\>
```

have 10 or more years of record and sites affected by regulation or diversions were excluded from further analysis. The remaining 333 sites formed the database for the two regionalization methods. Peak-flow data and basin and climatic characteristics data (explanatory variables) were compiled and calculated for sites in the database by using a geographic information system. These data also were included in the database. Preliminary multiple-regression analyses, using ordinary least-squares regression, were conducted to identify the best combination of explanatory variables for inclusion in the generalized least-squares analysis.

Generalized least-squares analysis was used to develop a set of equations for each region that relate the 2-, 5-, 10-, 25-, 50-, 100-, 200-, and 500-year recurrence interval peak flows to basin and climatic characteristics. Regression equations for region 7b included only one explanatory variable; equations for regions 1, 5, and 8 included the most explanatory variables (three). All regional regression equations required drainage area as an input variable. Three of the explanatory variables—north-facing slopes greater than 30 percent, basin slope, and slopes greater than 30 percent—have not been used previously in regional regression equations for estimating peak flows in Idaho. Model standard errors and standard errors of prediction also were calculated for each equation. The average standard error of prediction ranged from +143 to -34.2 percent. The range of errors was narrowest (-34.2 to +51.9) for region 5. Usually, errors were smaller and the range of errors was narrower for the middle recurrence intervals (10, 25, and 50 years) than for the lower and upper recurrence intervals (2, 5, 200, and 500 years).

The region-of-influence method also was adapted to the peak-flow and basin and climatic characteristics data for Idaho. The drainage area, mean basin elevation, mean annual precipitation, and forest cover were required to predict the 2-, 5-, 10-, 25-, 50-, 100-, 200-, and 500-year recurrence interval peak flows for a specified ungaged site. All 333 gaged sites in the database were used to determine the region of influence. The average root-mean-squared error for the region-of-influence method ranged from 55.5 percent to 72.4 percent. The RMSEs were generally larger for the ROI method, averaging greater than 10 percent for regions 1 through 7a. In region 5, the RMSEs were generally greater than 20 percent. In region 8, the RMSEs were generally smaller for the region-of-influence method than for the regional regression equations, and for region 7b, the RMSEs were smaller only for the 2-, 5-, 10-, and 25-year recurrence interval peak flows. Therefore, the region-of-influence method is not recommended for use in determining flood-frequency estimates for ungaged sites in Idaho because the results are less accurate and the calculations are more complex than those of regional regression equations. The regional regression equations are considered to be the primary method of estimating the magnitude and frequency of peak flows for ungaged sites on undiverted and unregulated streams in Idaho.

A computer program (*idregeq.exe*) automates the calculations required for the regional regression equations, site-specific errors of prediction, and the 90-percent confidence intervals.

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Tables 4, 5, and 9

Table 4. Basin and climatic characteristics for streamflow-gaging stations in Idaho and bordering States used in regional regression analysis

[DA, drainage area; E, mean basin elevation; F, percentage of forest cover in the basin; P, mean annual precipitation; BS, average basin slope; NF30, percentage of north-facing slopes greater than 30 percent; S30, percentage of slopes greater than 30 percent; mi^2, square miles; ft, feet; in., inches; ft/mi, feet per mile; ID, Idaho; MT, Montana; NV, Nevada; OR, Oregon; WA, Washington; WY, Wyoming; Y.N.P., Yellowstone National Park]

Map No.	Gaging station No.	Gaging station name	DA (mi^2)	E (ft)	F (percent)	P (in.)	BS (percent)	NF30 (percent)	S30 (percent)
			REGION 1						
1	12305500	Boulder Creek near Leonia, ID	55.3	4,686.9	92.0	48.30	37.1	21.8	69.4
2	12309000	Cow Creek near Bonners Ferry, ID	17.6	3,189.5	77.1	30.05	26.7	28.8	40.8
3	12310800	Trail Creek at Naples, ID	16.0	3,498.6	92.6	31.27	24.3	13.7	27.8
4	12311000	Deep Creek at Moravia, ID	133.1	3,257.0	72.6	30.36	21.2	9.7	27.0
5	12313500	Ball Creek near Bonners Ferry, ID	26.6	5,194.4	78.7	42.20	40.6	18.3	70.2
6	12316800	Mission Creek near Copeland, ID	12.5	4,084.4	94.5	29.15	25.4	5.8	33.2
7	12320500	Long Canyon Creek near Porthill, ID	29.9	5,347.3	89.5	41.32	46.4	22.7	81.4
8	12321000	Smith Creek near Porthill, ID	71.1	5,054.2	70.4	46.14	37.0	19.8	62.3
9	12392100	Trapper Creek near Clark Fork, ID	1.1	4,844.3	96.1	57.78	50.2	9.1	91.6
10	12392155	Lightning Creek at Clark Fork, ID	115.1	4,648.5	82.4	54.32	43.2	20.3	71.8
11	12392300	Pack River near Colburn, ID	121.4	4,280.6	62.6	38.15	32.2	15.9	52.4
12	12392800	Hornby Creek near Dover, ID	3.1	2,519.6	89.4	30.00	17.9	3.7	11.9
13	12393500	Priest River at outlet of Priest Lake near Coolin, ID	596.6	3,941.3	79.0	38.79	28.9	13.7	46.3
14	12393600	Binarch Creek near Coolin, ID	10.6	3,258.6	97.6	30.58	35.0	16.6	59.3
15	12396000	Calispell Creek near Dalkena, WA	68.2	3,622.5	79.6	36.71	30.1	20.0	51.8
16	12408500	Mill Creek near Colville, WA	82.5	3,520.8	89.4	37.74	29.6	13.9	46.2
17	12409000	Colville River at Kettle Falls, WA	1,011.0	2,904.3	77.0	27.57	22.3	9.0	28.2
18	12427000	Little Spokane River at Elk, WA	84.4	2,459.0	65.2	28.22	13.2	4.1	10.4
19	12429600	Deer Creek near Chattaroy, WA	31.0	2,683.7	65.3	27.61	15.3	4.4	9.0
20	12430370	Bigelow Gulch near Spokane, WA	4.4	2,245.2	23.9	19.37	9.7	0.6	2.6
21	12431000	Little Spokane River at Dartford, WA	634.9	2,397.7	54.6	25.11	12.2	2.8	9.4
			REGION 2						
22	12302500	Granite Creek near Libby, MT	23.7	5,275.3	66.4	52.96	54.1	26.7	82.4
23	12303100	Flower Creek near Libby, MT	11.3	5,466.8	76.7	52.64	48.3	30.0	71.2
24	12303500	Lake Creek at Troy, MT	125.0	4,069.2	87.3	43.94	38.5	21.0	62.8
25	12304250	Whitetail Creek near Yaak, MT	2.4	4,299.5	81.5	31.61	27.4	0.5	37.2
26	12304300	Cyclone Creek near Yaak, MT	5.7	4,627.2	96.9	40.99	33.9	30.1	63.5
27	12304400	Fourth of July Creek near Yaak, MT	7.8	4,468.8	96.7	38.86	35.9	26.7	72.6
28	12341000	Rattlesnake Creek at Missoula, MT	79.9	5,708.4	79.3	37.04	36.9	16.7	57.6
29	12345800	Camas Creek near Hamilton, MT	5.1	7,064.0	51.8	50.32	42.5	19.5	73.4
30	12347500	Blodgett Creek near Corvallis, MT	26.1	6,649.7	50.4	60.87	57.0	32.1	82.8
31	12350200	Gash Creek near Victor, MT	3.3	6,684.3	73.4	54.70	37.9	22.0	69.2

Table 4. Basin and climatic characteristics for streamflow-gaging stations in Idaho and bordering States used in regional regression analysis--Continued

Map No.	Gaging station No.	Gaging station name	DA (mi^2)	E (ft)	F (percent)	P (in.)	BS (percent)	NF30 (percent)	S30 (percent)
			REGION 2 -- Continued						
32	12350500	Kootenai Creek near Stevensville, MT	29.0	6,557.7	60.4	55.58	58.8	28.8	89.6
33	12352000	Lolo Creek above Sleeman Creek, near Lolo, MT	249.2	5,272.8	84.7	46.82	35.3	19.1	58.9
34	12353800	Thompson Creek near Superior, MT	12.0	4,648.3	88.2	39.04	41.2	27.3	76.2
35	12353850	East Fork Timber Creek near Haugan, MT	2.6	4,669.2	96.0	48.34	32.8	1.6	54.3
36	12354000	St. Regis River near St. Regis, MT	43.6	4,843.4	88.3	44.49	47.2	30.4	84.6
37	12354100	North Fork Little Joe Creek near St. Regis, MT	14.4	4,854.3	89.8	42.42	45.6	28.5	83.1
38	12389500	Thompson River near Thompson Falls, MT	641.5	4,567.1	85.8	29.56	30.0	15.9	47.0
39	12390700	Prospect Creek at Thompson Falls, MT	181.5	4,437.3	93.1	43.68	43.5	27.8	79.6
40	12411000	North Fork Coeur d'Alene River above Shoshone Creek, near Prichard, ID	334.0	3,947.0	89.7	48.25	40.8	24.7	75.6
41	12413000	North Fork Coeur d'Alene River at Enaville, ID	893.7	3,835.9	88.9	45.38	41.9	25.4	77.6
42	12413100	Boulder Creek at Mullan, ID	3.1	5,212.4	93.2	49.41	46.7	33.1	83.0
43	12413140	Placer Creek at Wallace, ID	15.0	4,411.0	94.2	41.53	49.6	31.2	88.8
44	12413150	South Fork Coeur d'Alene River at Silverton, ID	105.6	4,615.4	89.8	42.52	45.8	27.5	82.3
45	12413200	Montgomery Creek near Kellogg, ID	4.5	3,648.3	91.8	40.23	48.0	13.6	89.3
46	12413210	South Fork Coeur d'Alene at Elizabeth Park near Kellogg, ID	181.8	4,301.2	88.5	43.34	45.8	27.2	82.5
47	12413470	South Fork Coeur d'Alene River near Pinehurst, ID	287.1	4,096.4	83.5	45.09	44.6	26.9	80.7
48	12413500	Coeur d'Alene River at Cataldo, ID	1,207.4	3,878.0	87.3	45.01	42.3	25.5	77.8
49	12413700	Latour Creek near Cataldo, ID	24.8	4,316.0	85.6	54.84	41.8	27.9	81.6
50	12414500	St. Joe River at Calder, ID	1,024.5	4,545.6	89.8	46.95	41.3	24.7	74.4
51	12414900	St. Maries River near Santa, ID	272.6	3,592.6	80.6	37.73	25.1	12.5	34.9
52	12415000	St. Maries River at Lotus, ID	434.5	3,465.5	82.2	35.63	23.8	11.4	31.7
53	12415100	Cherry Creek near St. Maries, ID	7.1	3,308.1	86.4	31.71	30.3	23.5	51.3
54	12415200	Plummer Creek Tributary at Plummer, ID	2.0	2,966.3	35.9	20.00	15.2	1.5	9.9
55	12416000	Hayden Creek below North Fork, near Hayden Lake, ID	21.5	3,564.7	95.1	38.75	41.8	25.3	81.2
56	13336500	Selway River near Lowell, ID	1,913.1	5,511.8	82.8	40.58	44.2	24.1	785.6
57	13336600	Swiftwater Creek near Lowell, ID	6.2	3,814.8	93.7	33.22	42.7	39.6	80.2
58	13336650	East Fork Papoose Creek near Powell Ranger Station, ID	4.5	4,832.2	82.4	47.61	47.2	17.1	87.9
59	13336850	Weir Creek near Powell Ranger Station, ID	12.2	4,817.1	86.5	48.18	48.7	13.9	88.5
60	13336900	Fish Creek near Lowell, ID	88.3	4,467.2	91.3	46.34	34.7	13.7	55.7
61	13337000	Lochsa River near Lowell, ID	1,179.4	5,197.2	88.2	46.62	38.5	20.4	63.5
62	13340500	North Fork Clearwater River at Bungalow Ranger Station, ID	997.5	4,888.8	82.2	52.47	39.0	22.1	68.1
63	13340600	North Fork Clearwater River near Canyon Ranger Station, ID	1,294.2	4,732.9	82.9	51.40	40.4	22.7	69.9
64	13341300	Bloom Creek near Bovill, ID	3.0	3,716.0	86.8	48.07	32.0	27.6	55.6
65	13341400	East Fork Potlatch River near Bovill, ID	42.7	3,617.2	86.0	42.67	26.3	14.0	36.4

Table 4. Basin and climatic characteristics for streamflow-gaging stations in Idaho and bordering States used in regional regression analysis--Continued

Map No.	Gaging station No.	Gaging station name	DA (mi^2)	E (ft)	F (percent)	P (in.)	BS (percent)	NF30 (percent)	S30 (percent)
			REGION 3						
66	12423550	Hangman Creek Tributary near Latah, WA	2.3	2,693.4	1.1	20.41	11.4	1.7	1.9
67	12423700	South Fork Rock Creek Tributary near Fairfield, WA	0.6	2,720.9	7.9	19.91	11.0	2.6	3.2
68	12423900	Stevens Creek Tributary near Moran, WA	2.0	2,671.8	9.9	18.97	17.2	0.9	2.0
69	12424000	Hangman Creek at Spokane, WA	674.9	2,647.1	19.4	20.83	10.5	2.3	6.7
70	13334700	Asotin Creek below Kearney Gulch near Asotin, WA	170.5	3,752.2	30.5	23.01	35.4	20.7	57.5
71	13335200	Critchfield Draw near Clarkston, WA	2.0	1,472.6	0.2	11.90	12.7	0.9	3.9
72	13341100	Cold Springs Creek near Craigmont, ID	8.2	4,040.1	10.7	20.00	8.9	0.2	1.0
73	13341500	Potlatch River at Kendrick, ID	453.7	2,969.1	59.8	29.51	18.2	5.5	17.8
74	13342450	Lapwai Creek near Lapwai, ID	268.9	3,149.2	30.7	19.31	18.9	7.7	22.2
75	13343450	Dry Creek at mouth near Clarkston, WA	7.5	1,458.4	0.2	12.08	8.6	0.1	1.4
76	13343800	Meadow Creek near Central Ferry, WA	67.2	1,898.5	0.0	16.12	14.2	2.3	6.7
77	13344500	Tucannon River near Starbuck, WA	431.8	2,943.7	23.7	23.98	26.4	11.9	36.0
78	13344700	Deep Creek Tributary near Polatch, ID	2.9	3,156.8	87.6	28.67	24.3	17.8	27.1
79	13344800	Deep Creek near Potlatch, ID	35.8	2,977.9	46.4	24.92	18.7	5.0	19.8
80	13345000	Palouse River near Potlatch, ID	316.0	3,165.1	63.4	30.07	21.2	9.0	25.8
81	13346100	Palouse River at Colfax, WA	491.7	2,963.6	41.7	26.93	17.7	6.2	17.8
82	13346300	Crumarine Creek near Moscow, ID	2.4	3,694.1	79.3	29.55	27.4	10.0	41.1
83	13346800	Paradise Creek at University of Idaho, at Moscow, ID	17.6	2,844.2	12.5	24.53	11.8	1.0	6.0
84	13348000	South Fork Palouse River at Pullman, WA	126.9	2,745.5	6.9	23.76	11.9	0.8	3.3
85	13348500	Missouri Flat Creek at Pullman, WA	27.1	2,652.2	0.6	23.23	10.0	0.0	0.0
86	13349210	Palouse River below South Fork at Colfax, WA	788.7	2,842.0	27.4	25.33	15.5	4.2	12.1
87	13349400	Pine Creek at Pine City, WA	304.6	2,527.0	1.6	19.00	9.1	0.5	1.2
88	13350500	Union Flat Creek near Colfax, WA	189.8	2,691.9	0.0	20.97	10.5	0.5	1.1
89	14016000	Dry Creek near Walla Walla, WA	48.5	2,342.9	18.4	30.10	21.4	8.9	23.7
90	14016500	East Fork Touchet River near Dayton, WA	106.2	3,820.0	59.8	42.10	38.9	21.0	65.9
91	14017000	Touchet River at Bolles, WA	363.3	2,928.8	31.7	30.50	27.3	13.4	38.5
			REGION 4						
92	13185500	Cottonwood Creek at Arrowrock Reservoir, ID	20.8	5,198.1	36.8	19.08	39.8	18.4	70.7
93	13196500	Bannock Creek near Idaho City, ID	4.8	5,313.2	60.4	22.08	32.9	26.2	57.4
94	13200000	Mores Creek above Robie Creek, near Arrowrock Dam, ID	397.0	5,070.8	66.3	24.76	31.3	16.7	51.0
95	13200500	Robie Creek near Arrowrock Dam, ID	16.0	4,680.6	65.0	23.34	39.8	23.4	70.6
96	13201000	Mores Creek near Arrowrock, ID	424.4	5,024.2	65.0	24.48	31.7	17.0	52.0
97	13207000	Spring Valley Creek near Eagle, ID	19.2	4,017.4	8.0	19.42	24.3	9.3	30.2
98	13207500	Dry Creek near Eagle, ID	59.4	3,963.4	11.7	20.39	25.3	8.8	34.3
99	13216500	North Fork Malheur River above Beulah Reservoir near Beulah, OR	342.5	5,360.8	52.7	23.79	21.6	6.0	23.2

Table 4. Basin and climatic characteristics for streamflow-gaging stations in Idaho and bordering States used in regional regression analysis--Continued

Map No.	Gaging station No.	Gaging station name	DA (mi^2)	E (ft)	F (percent)	P (in.)	BS (percent)	NF30 (percent)	S30 (percent)
		REGION 4--Continued							
100	13248900	Cottonwood Creek near Horseshoe Bend, ID	7.0	3,882.5	0.0	17.16	23.9	15.2	26.3
101	13250600	Big Willow Creek near Emmett, ID	55.2	4,099.3	4.8	15.88	23.6	7.3	28.0
102	13250650	Fourmile Creek near Emmett, ID	6.2	3,804.1	1.7	12.88	22.9	2.9	21.4
103	13251300	West Branch Weiser River near Tamarack, ID	4.0	4,947.6	81.5	39.75	27.3	3.2	41.5
104	13251500	Weiser River at Tamarack, ID	36.6	4,654.2	87.8	34.61	22.3	4.9	27.1
105	13252500	East Fork Weiser River near Council, ID	2.3	6,883.5	76.0	40.00	27.0	16.9	36.5
106	13253500	Weiser River at Starkey, ID	105.4	4,969.7	88.1	32.34	26.5	10.7	38.0
107	13256000	Weiser River near Council, ID	391.9	4,668.2	64.6	29.64	24.2	9.6	32.7
108	13257000	Middle Fork Weiser River near Mesa, ID	86.1	5,430.2	74.1	34.00	27.4	11.1	38.3
109	13258500	Weiser River near Cambridge, ID	596.4	4,636.5	58.2	29.23	23.5	8.7	30.6
110	13260000	Pine Creek near Cambridge, ID	55.3	4,751.8	42.3	22.43	26.4	10.0	37.9
111	13261000	Little Weiser River near Indian Valley, ID	79.5	5,313.9	67.1	28.23	26.9	11.2	36.5
112	13266000	Weiser River near Weiser, ID	1,448.3	4,141.3	32.7	22.23	19.3	6.4	22.1
113	13267000	Mann Creek near Weiser, ID	56.8	4,846.2	55.4	22.12	31.6	10.6	53.4
114	13267100	Deer Creek near Midvale, ID	4.3	3,233.7	1.1	10.00	15.7	0.5	6.1
115	13269300	North Fork Burnt River near Whitney, OR	110.8	4,901.1	81.6	25.11	18.7	4.5	17.7
116	13270800	South Fork Burnt River above Barney Creek near Unity, OR	38.9	5,823.5	91.6	28.59	28.2	16.9	42.0
117	13275500	Powder River near Baker, OR	205.2	5,224.6	74.5	24.67	26.5	9.6	40.8
118	13288200	Eagle Creek above Skull Creek near New Bridge, OR	155.7	5,742.6	67.6	47.53	40.5	14.5	63.7
119	13289100	Immigrant Gulch near Richlavel, OR	6.7	3,581.4	1.4	24.97	25.4	3.1	32.3
120	13289600	East Brownlee Creek at Brownlee Ranger Station, ID	7.4	5,913.0	79.2	30.00	44.9	18.5	78.9
121	13289960	Wildhorse River at Brownlee Dam, ID	177.1	5,037.5	62.2	27.53	29.4	14.3	43.3
122	13290190	Pine Creek near Oxbow, OR	298.5	4,287.7	50.2	33.71	27.4	9.8	40.0
123	13291000	Imnaha River above Gumboot Creek, OR	99.8	6,374.4	64.6	56.25	37.0	21.0	58.7
124	13291200	Mahogany Creek near Homestead, OR	4.1	5,192.1	75.4	37.19	33.5	18.5	53.2
125	13315500	Mud Creek near Tamarack, ID	15.1	4,742.2	93.0	35.36	27.4	6.7	45.0
126	13316500	Little Salmon River at Riggins, ID	576.1	5,421.1	71.8	29.61	33.4	15.5	51.5
127	13316800	North Fork Skookumchuck Creek near White Bird, ID	15.3	5,031.2	69.3	30.22	30.6	15.8	44.2
128	13317000	Salmon River at White Bird, ID	13,418.3	6,753.8	58.3	24.72	37.7	19.1	60.3
129	13317200	Johns Creek near Grangeville, ID	5.0	3,961.5	33.1	24.22	11.7	8.5	10.9
130	13319000	Grande Ronde River at La Grande, OR	687.4	4,582.0	68.4	27.57	20.3	6.5	21.8
131	13320000	Catherine Creek near Union, OR	104.1	5,263.8	85.9	39.66	28.6	10.6	40.8
132	13323600	Indian Creek near Imbler, OR	24.8	5,515.7	77.1	43.58	21.3	6.3	20.8
133	13329500	Hurricane Creek near Joseph, OR	29.6	7,461.3	47.0	64.64	57.2	22.9	87.0
134	13330000	Lostine River near Lostine, OR	71.5	6,893.5	52.1	56.69	49.2	22.1	77.2

Table 4. Basin and climatic characteristics for streamflow-gaging stations in Idaho and bordering States used in regional regression analysis--Continued

Map No.	Gaging station No.	Gaging station name	DA (mi^2)	E (ft)	F (percent)	P (in.)	BS (percent)	NF30 (percent)	S30 (percent)
		REGION 4--Continued							
135	13330500	Bear Creek near Wallowa, OR	72.1	5,804.7	67.2	44.74	45.6	23.2	75.0
136	13331500	Minam River at Minam, OR	239.2	5,699.5	66.4	46.47	43.5	21.3	70.5
137	13337200	Red Horse Creek near Elk City, ID	9.1	5,052.5	93.9	36.37	27.9	11.9	42.3
138	13337500	South Fork Clearwater River near Elk City, ID	260.8	5,095.1	91.7	35.30	24.1	10.1	28.8
139	13337700	Peasley Creek near Golden, ID	14.2	4,880.8	94.3	35.81	35.0	9.5	57.9
140	13338000	South Fork Clearwater River near Grangeville, ID	843.4	5,116.5	91.8	34.88	29.7	14.0	42.4
141	13338200	Sally Ann Creek near Stites, ID	13.8	3,142.8	57.6	31.08	24.8	16.6	32.0
142	13338500	South Fork Clearwater River at Stites, ID	1,168.3	4,546.6	70.5	31.31	25.7	11.9	35.1
143	13339000	Clearwater River at Kamiah, ID	4,827.4	4,956.2	77.4	38.29	36.2	19.1	58.6
144	13339500	Lolo Creek near Greer, ID	241.4	3,528.6	84.1	31.53	22.6	8.4	25.5
145	13339700	Canal Gulch Creek at Pierce Ranger Station, ID	6.4	3,539.5	92.2	40.00	17.5	1.1	8.5
146	13339900	Deer Creek near Orofino, ID	5.2	2,955.8	82.6	29.82	18.0	7.2	17.7
147	13340000	Clearwater River at Orofino, ID	5,507.9	4,736.4	76.6	37.36	34.4	17.7	54.5
148	14010000	South Fork Walla Walla River near Milton, OR	61.9	4,273.1	68.3	46.44	46.3	21.9	74.7
149	14011000	North Fork Walla Walla River near Milton, OR	42.6	3,640.0	57.2	42.17	42.1	23.9	71.2
150	14013000	Mill Creek near Walla Walla, WA	58.8	3,933.2	68.6	47.97	50.5	28.8	85.5
151	14013500	Blue Creek near Walla Walla, WA	17.1	3,136.4	45.7	40.52	38.3	24.9	68.8
		REGION 5							
152	12343400	East Fork Bitterroot River near Conner, MT	379.3	6,361.7	78.6	28.42	33.2	18.1	55.1
153	12346500	Skalkaho Creek near Hamilton, MT	88.1	6,676.0	86.4	29.55	38.8	22.5	67.5
154	12351000	Burnt Fork Bitterroot River near Stevensville, MT	73.0	6,495.2	79.6	30.60	36.5	21.3	62.0
155	12351400	Eightmile Creek near Florence, MT	20.8	5,389.4	62.1	24.51	39.1	24.2	69.3
156	13135200	Prairie Creek near Ketchum, ID	17.3	8,558.1	59.0	34.44	45.9	24.1	72.1
157	13135500	Big Wood River near Ketchum, ID	137.5	8,204.0	55.8	31.42	40.6	20.8	67.5
158	13135800	Adams Gulch near Ketchum, ID	10.5	7,373.5	61.5	30.69	42.5	32.9	79.2
159	13136500	Warm Springs Creek at Guyer Hot Springs, near Ketchum, ID	92.6	7,696.0	59.7	35.77	42.6	23.1	77.8
160	13139500	Big Wood River at Hailey, ID	627.6	7,685.6	43.2	29.35	42.7	22.1	74.0
161	13141000	Big Wood River near Bellevue, ID	786.2	7,347.3	35.5	26.45	40.2	20.8	69.3
162	13141400	Deer Creek near Fairfield, ID	11.8	6,496.3	30.1	19.80	33.4	13.1	62.2
163	13184200	Roaring River near Rocky Bar, ID	22.1	7,274.7	61.3	41.26	32.6	15.7	46.8
164	13184800	Beaver Creek near Lowman, ID	10.0	5,796.4	52.1	32.14	24.2	7.8	29.9
165	13185000	Boise River near Twin Springs, ID	831.6	6,415.7	50.2	32.42	44.3	23.2	75.1
166	13186000	South Fork Boise River near Featherville, ID	641.6	7,025.2	50.6	34.72	42.1	21.5	74.4
167	13186500	Lime Creek near Bennett, ID	133.6	6,276.7	22.4	22.40	29.3	11.4	47.3
168	13187000	Fall Creek near Anderson Ranch Dam, ID	55.6	6,171.1	59.2	32.16	33.6	14.0	59.3
169	13234300	Fivemile Creek nr Lowman, ID	11.3	6,623.7	49.9	32.33	44.6	14.7	76.2

Table 4. Basin and climatic characteristics for streamflow-gaging stations in Idaho and bordering States used in regional regression analysis--Continued

Map No.	Gaging station No.	Gaging station name	DA (mi^2)	E (ft)	F (percent)	P (in.)	BS (percent)	NF30 (percent)	S30 (percent)
		REGION 5--Continued							
170	13235000	South Fork Payette River at Lowman, ID	449.3	6,824.5	54.3	34.51	46.7	23.2	76.6
171	13235100	Rock Creek at Lowman, ID	16.5	5,793.4	63.3	31.40	39.5	25.9	72.2
172	13237300	Danskin Creek near Crimes Pass, ID	10.0	4,779.2	68.8	26.49	46.3	16.1	83.7
173	13238300	Deep Creek near McCall, ID	3.6	7,255.3	60.3	49.73	22.5	2.5	23.4
174	13240000	Lake Fork Payette River above Jumbo Creek, near McCall, ID	48.7	6,921.9	71.6	37.22	42.1	16.5	67.9
175	13240500	Lake Fork Payette River above Reservoir near McCall, ID	51.7	6,905.7	72.6	36.82	41.0	15.7	65.6
176	13245400	Tripod Creek at Smiths Ferry, ID	8.6	5,514.1	87.7	28.13	19.8	3.6	18.3
177	13292400	Beaver Creek near Stanley, ID	14.9	8,255.9	57.7	41.59	35.4	22.1	56.9
178	13292500	Salmon River near Obsidian, ID	93.9	8,181.1	56.9	34.66	32.8	17.8	53.1
179	13293000	Alturas Lake Creek near Obsidian, ID	35.6	8,161.5	47.1	44.47	37.6	19.0	60.4
180	13295000	Valley Creek at Stanley, ID	148.9	7,318.8	63.0	23.94	26.1	12.0	37.0
181	13295500	Salmon River below Valley Creek, at Stanley, ID	510.4	7,786.2	54.9	29.61	30.4	14.6	45.2
182	13296000	Yankee Fork Salmon River near Clayton, ID	187.3	7,992.1	74.5	27.11	41.0	22.7	71.1
183	13296500	Salmon River below Yankee Fork, near Clayton, ID	811.1	7,791.6	61.9	27.95	33.6	17.1	53.7
184	13297100	Peach Creek near Clayton, ID	7.6	7,809.8	78.1	22.53	47.1	16.6	87.1
185	13308500	Middle Fork Salmon River near Cape Horn, ID	133.8	7,482.6	70.8	28.40	26.6	11.6	40.2
186	13309000	Bear Valley Creek near Cape Horn, ID	181.7	7,060.3	70.1	30.02	20.2	7.6	24.7
187	13309220	Middle Fork Salmon River near Yellow Pine, ID	1,038.7	7,189.7	68.9	29.00	38.4	20.3	64.1
188	13310000	Big Creek near Big Creek, ID	451.5	6,981.2	78.6	28.71	44.3	24.6	74.0
189	13310500	South Fork Salmon River near Knox, ID	91.7	6,631.3	88.7	37.46	31.7	18.3	52.9
190	13310700	South Fork Salmon River near Krassel Ranger Station, ID	329.3	6,381.8	83.7	33.62	38.0	19.9	63.8
191	13311000	East Fork South Fork Salmon River at Stibnite, ID	19.3	7,724.4	83.7	34.05	35.3	20.4	62.6
192	13311500	East Fork South Fork Salmon River near Stibnite, ID	42.9	7,619.9	77.3	30.88	40.8	22.8	72.5
193	13312000	East Fork South Fork Salmon River near Yellow Pine, ID	106.9	7,404.6	78.2	30.02	41.7	22.2	73.0
194	13313000	Johnson Creek at Yellow Pine, ID	216.4	7,135.2	91.7	34.31	28.2	11.3	40.7
195	13313500	Secesh River near Burgdorf, ID	100.5	6,963.9	82.7	43.91	24.8	10.7	61.8
196	13314000	South Fork Salmon River near Warren, ID	1,164.0	6,696.9	81.2	33.15	37.4	18.4	60.5
197	13315000	Salmon River near French Creek, ID	12,228.0	6,913.7	57.4	24.41	37.8	19.3	60.4
		REGION 6							
198	06013500	Big Sheep Creek below Muddy Creek near Dell, MT	277.0	7,928.2	14.5	18.82	24.1	10.1	31.8
199	06015500	Grasshopper Creek near Dillon, MT	349.0	6,940.1	28.9	19.22	18.8	5.6	19.6
200	06019500	Ruby River above reservoir near Alder, MT	525.5	7,235.2	26.0	22.93	20.1	6.2	20.5
201	13108500	Camas Creek at Eighteenmile Shearing Corral, near Kilgore, ID	228.4	6,943.3	39.4	26.84	12.8	3.2	12.8
202	13112000	Camas Creek at Camas, ID	393.9	6,428.8	22.9	21.10	8.6	1.9	7.5

Table 4. Basin and climatic characteristics for streamflow-gaging stations in Idaho and bordering States used in regional regression analysis--Continued

Map No.	Gaging station No.	Gaging station name	DA (mi^2)	E (ft)	F (percent)	P (in.)	BS (percent)	NF30 (percent)	S30 (percent)
		REGION 6--Continued							
203	13112900	Huntley Canyon at Spencer, ID	4.0	6,820.0	58.0	17.33	24.8	11.2	33.1
204	13113000	Beaver Creek at Spencer, ID	123.2	7,027.5	29.9	20.29	19.6	7.9	23.5
205	13113500	Beaver Creek at Dubois, ID	238.7	6,696.9	24.4	19.42	16.7	5.1	18.8
206	13117200	Main Fork near Goldburg, ID	16.2	8,734.8	49.7	26.30	32.6	10.9	53.0
207	13117300	Sawmill Creek near Goldburg, ID	74.2	8,380.5	54.1	23.79	32.7	14.2	53.7
208	13120000	North Fork Big Lost River at Wild Horse, near Chilly, ID	114.7	8,659.7	58.1	29.80	43.1	22.0	72.1
209	13120500	Big Lost River at Howell Ranch, near Chilly, ID	440.4	8,626.3	37.9	26.96	37.8	17.9	60.8
210	13128900	Lower Cedar Creek above Diversion 3, near Mackay, ID	8.4	9,461.0	21.0	26.61	66.2	17.1	94.2
211	13297300	Holman Creek near Clayton, ID	6.1	7,298.7	69.6	20.81	36.6	24.9	61.5
212	13297330	Thompson Creek near Clayton, ID	29.5	7,618.4	68.9	22.60	47.7	23.5	85.8
213	13297350	Bruno Creek near Clayton, ID	6.4	7,520.2	66.3	21.74	40.8	21.2	68.3
214	13297355	Squaw Creek below Bruno Creek, near Clayton, ID	71.6	7,729.2	73.0	25.17	36.3	16.3	60.2
215	13297450	Little Boulder Creek near Clayton, ID	18.3	8,951.8	39.2	31.98	41.3	23.5	64.3
216	13298000	East Fork Salmon River near Clayton, ID	540.2	8,092.5	31.7	26.00	38.2	20.6	62.7
217	13298300	Malm Gulch near Clayton, ID	9.3	7,015.7	9.4	20.99	36.3	16.8	63.5
218	13299000	Challis Creek near Challis, ID	84.6	7,780.8	62.4	25.59	37.2	18.3	62.0
219	13301700	Morse Creek above Diversion near May, ID	17.9	8,178.6	45.4	21.25	51.4	26.7	87.5
220	13301800	Morse Creek near May, ID	20.0	7,926.5	40.7	20.24	47.9	24.1	80.6
221	13302500	Salmon River at Salmon, ID	3,746.1	7,397.5	37.3	21.63	33.4	16.7	52.9
222	13305000	Lemhi River near Lemhi, ID	907.1	7,430.9	24.3	15.62	25.2	11.9	36.9
223	13305500	Lemhi River at Salmon, ID	1,258.0	7,108.2	24.9	15.26	26.4	12.4	39.1
224	13305700	Dahlonega Creek at Gibbonsville, ID	32.5	6,184.7	90.9	25.32	45.2	18.8	86.3
225	13305800	Hughes Creek near North Fork, ID	20.5	6,707.4	83.9	27.88	41.3	20.7	75.8
226	13306000	North Fork Salmon River at North Fork, ID	210.3	6,258.1	77.8	22.87	43.6	23.1	78.0
227	13306500	Panther Creek near Shoup, ID	520.7	7,028.2	80.2	24.00	38.6	20.9	62.2
228	13307000	Salmon River near Shoup, ID	6,236.7	7,154.3	41.1	20.37	33.3	16.6	52.8
		REGION 7a							
229	10315500	Marys River above Hot Springs Creek near Deeth, NV	389.8	6,589.8	2.3	15.19	17.5	5.3	21.8
230	10329500	Martin Creek near Paradise Valley, NV	176.2	6,210.4	4.1	21.88	21.0	8.3	26.4
231	10352500	McDermitt Creek near Mc Dermitt, NV	225.4	5,890.4	1.4	17.00	17.3	4.3	17.2
232	10353000	East Fork Quinn River near McDermitt, NV	137.9	6,117.4	2.1	22.24	22.2	10.0	28.0
233	10396000	Donner And Blitzen River near Frenchglen, OR	204.7	6,197.6	22.4	29.07	16.2	5.5	15.2
234	10406500	Trout Creek near Denio, NV	86.7	6,025.9	3.9	16.86	23.1	9.0	31.2
235	13155200	Burns Gulch near Glenns Ferry, ID	0.7	6,089.9	1.3	25.00	30.7	1.7	53.2
236	13155300	Little Canyon Creek at Stout Crossing near Glenns Ferry, ID	14.2	5,927.8	3.0	23.47	25.2	8.3	36.8

Table 4. Basin and climatic characteristics for streamflow-gaging stations in Idaho and bordering States used in regional regression analysis--Continued

Map No.	Gaging station No.	Gaging station name	DA (mi^2)	E (ft)	F (percent)	P (in.)	BS (percent)	NF30 (percent)	S30 (percent)
		REGION 7a--Continued							
237	13161200	Seventy Six Creek near Charleston, NV	3.6	7,067.5	1.3	24.49	27.4	6.6	38.9
238	13161300	Meadow Creek near Rowland, NV	57.6	6,597.0	3.6	19.58	25.7	11.9	35.2
239	13162200	Jarbidge River at Jarbidge, NV	22.6	8,260.7	37.8	33.79	48.8	22.7	85.8
240	13162400	Buck Creek near Jarbidge, NV	25.8	7,069.6	13.7	22.42	17.9	7.7	18.8
241	13162500	East Fork Jarbidge River near Three Creek, ID	84.9	7,603.0	24.5	24.77	35.3	16.1	55.2
242	13162600	Columbet Creek near Jarbidge, NV	3.5	7,028.8	8.4	22.15	16.8	7.1	14.1
243	13169500	Big Jacks Creek near Bruneau, ID	243.7	5,170.0	0.0	13.81	10.1	2.3	7.4
244	13170000	Little Jacks Creek near Bruneau, ID	103.4	5,067.4	0.1	14.22	13.2	3.8	11.5
245	13170100	Sugar Creek Tributary near Grasmere, ID	4.5	4,856.2	0.0	10.00	8.0	0.0	0.2
246	13172200	Fossil Creek near Oreana, ID	16.7	3,879.7	2.1	9.79	11.4	4.2	11.0
247	13172666	West Fork Reynolds Creek near Reynolds, ID	0.4	6,821.4	40.2	15.00	17.5	6.0	10.4
248	13172668	East Fork Reynolds Creek near Reynolds, ID	0.2	6,810.7	3.3	25.00	13.3	0.4	0.6
249	13172680	Reynolds Creek at Toolgate Weir near Reynolds, ID	18.7	6,133.6	38.4	21.22	23.0	11.1	24.9
250	13172720	Macks Creek near Reynolds, ID	12.5	4,883.0	11.1	13.64	21.1	7.7	21.6
251	13172735	Salmon Creek near Reynolds, ID	13.1	5,001.8	5.5	14.66	26.1	9.7	36.3
252	13172740	Reynolds Creek at Outlet Weir near Reynolds, ID	91.8	5,015.7	12.4	14.83	20.2	7.2	20.7
253	13172800	Little Squaw Creek Tributary near Marsing, ID	1.8	4,447.6	0.0	10.00	14.3	0.1	8.3
254	13178000	Jordan Creek above Lone Tree Creek, near Jordan Vallley, ID	454.2	5,781.8	38.9	26.15	19.5	5.8	21.8
255	13210300	Bryans Run near Boise, ID	9.1	3,605.5	0.0	10.23	3.2	0.0	0.0
256	13226500	Bully Creek at Warmsprings near Vale, OR	535.3	4,133.8	0.8	12.26	17.4	3.7	15.3
		REGION 7b							
257	10119000	Little Malad River above Elkhorn Reservoir, near Malad City, ID	107.1	6,070.2	8.1	13.20	17.7	6.1	17.8
258	10122500	Devil Creek above Campbell Creek, near Malad City, ID	12.5	5,986.6	9.4	15.08	17.5	4.7	17.9
259	10123000	Devil Creek above Evans Dividers, near Malad City, ID	34.0	5,883.8	11.1	16.79	20.8	6.6	24.4
260	10172940	Dove Creek near Park Valley, UT	28.7	6,681.4	0.7	17.00	17.5	3.7	13.7
261	13057600	Homer Creek near Herman, ID	26.7	6,477.2	14.9	15.65	9.0	0.6	1.4
262	13057940	Willow Creek below Tex Creek near Ririe, ID	431.4	6,422.9	19.2	16.61	13.3	2.8	8.4
263	13073700	Robbers Roost Creek near McCammon, ID	3.9	6,767.0	41.5	24.88	42.4	21.8	77.0
264	13075000	Marsh Creek near McCammon, ID	367.4	5,587.7	9.0	14.30	16.8	6.4	20.2
265	13075600	North Fork Pocatello Creek near Pocatello, ID	14.0	5,756.2	7.7	15.00	21.2	8.0	17.3
266	13076200	Bannock Creek near Pocatello, ID	407.3	5,545.4	7.3	16.28	16.4	6.9	18.7
267	13077700	George Creek near Yost, UT	7.9	8,483.9	40.7	23.66	32.3	29.7	51.8
268	13079200	Cassia Creek near Elba, ID	81.2	6,460.8	16.3	17.39	23.5	12.2	33.0
269	13083000	Trapper Creek near Oakley, ID	52.4	6,339.4	6.2	17.39	28.1	14.4	41.3
270	13092000	Rock Creek near Rock Creek, ID	81.6	6,350.2	9.4	14.46	31.6	13.8	48.7

Table 4. Basin and climatic characteristics for streamflow-gaging stations in Idaho and bordering States used in regional regression analysis--Continued

Map No.	Gaging station No.	Gaging station name	DA (mi^2)	E (ft)	F (percent)	P (in.)	BS (percent)	NF30 (percent)	S30 (percent)
		REGION 7b--Continued							
271	13145700	Schooler Screek near Gooding, ID	2.1	5,624.1	0.0	10.00	10.1	0.2	2.0
272	13147300	Muldoon Creek near Garfield Guard Station, ID	12.3	8,395.8	30.8	25.00	47.4	12.7	79.0
273	13148000	Little Wood River at Campbell Ranch near Carey, ID	263.4	7,045.9	17.9	22.03	34.9	13.5	57.5
		REGION 8							
274	06037500	Madison River near West Yellowstone, MT	434.9	7,900.0	93.9	42.30	11.3	2.4	7.9
275	09223000	Hams Fork below Pole Creek near Frontier, WY	128.6	8,466.6	72.8	31.97	20.4	5.0	19.5
276	10015700	Sulphur Creek above reservoir, below La Chapelle Creek, near Evanston, WY	58.5	7,971.5	25.4	21.62	9.6	0.3	1.2
277	10040000	Thomas Fork near Geneva, ID	45.4	7,243.6	24.8	23.80	26.5	8.1	36.9
278	10040500	Salt Creek near Geneva, ID	38.1	7,448.4	51.3	26.84	27.9	8.3	42.9
279	10041000	Thomas Fork near Wyoming-Idaho State Line, WY	113.8	7,330.7	36.5	25.13	27.4	8.7	40.7
280	10047500	Montpelier Creek at Irrigators Weir, near Montpelier, ID	50.6	7,360.5	28.5	21.49	32.0	14.1	52.6
281	10058600	Bloomington Creek at Bloomington, ID	24.3	7,684.3	37.6	35.10	27.4	15.7	40.5
282	10069000	Georgetown Creek near Georgetown, ID	21.9	7,824.2	55.4	26.14	40.6	19.6	70.8
283	10072800	Eightmile Creek near Soda Springs, ID	17.2	7,598.6	75.5	30.73	29.9	15.1	47.3
284	10076400	Soda Creek at Fivemile Meadows, near Soda Springs, ID	42.5	6,193.0	1.2	18.42	5.1	0.8	3.4
285	10077000	Soda Creek near Soda Springs, ID	50.9	6,184.9	2.3	18.19	6.1	1.7	5.5
286	10084500	Cottonwood Creek near Cleveland, ID	62.4	6,720.9	40.4	23.61	20.9	5.8	21.8
287	10089500	Mink Creek near Mink Creek, ID	68.4	6,534.7	40.0	26.57	28.6	14.9	42.4
288	10090800	Battle Creek Tributary near Treasureton, ID	4.7	5,837.2	2.2	15.10	17.4	4.8	10.3
289	10093000	Cub River near Preston, ID	30.4	7,384.3	53.7	36.05	31.3	13.9	49.4
290	10096000	Cub River above Maple Creek near Franklin, ID	23.2	5,691.9	2.5	14.22	19.8	5.1	18.0
291	10099000	High Creek near Richmond, UT	16.3	7,655.4	62.2	40.94	49.4	30.6	86.6
292	13010000	Snake River at south boundary of Y.N.P., WY	477.4	7,232.2	82.6	47.68	15.9	5.6	14.8
293	13010065	Snake River above Jackson Lake at Flagg Ranch, WY	502.5	8,199.4	82.8	47.42	15.8	5.5	14.7
294	13011500	Pacific Creek at Moran, WY	162.7	8,134.7	72.4	36.25	20.3	6.1	20.8
295	13011800	Blackrock Creek Tributary near Moran, WY	2.5	9,690.1	39.2	39.20	22.8	2.8	23.2
296	13011900	Buffalo Fork above Lava Creek near Moran, WY	330.1	8,951.0	59.7	37.05	27.0	12.1	33.9
297	13012000	Buffalo Fork near Moran, WY	370.2	8,815.8	60.2	35.58	26.3	11.5	32.8
298	13014500	Gros Ventre River at Kelly, WY	608.0	8,863.0	62.6	31.62	23.3	8.3	26.9
299	13015000	Gros Ventre River at Zenith, WY	627.2	8,792.9	61.5	31.27	22.8	8.1	26.3
300	13018300	Cache Creek near Jackson, WY	10.7	8,291.9	75.7	34.72	40.3	21.0	71.2
301	13019210	Rim Draw near Bondurant, WY	4.7	8,030.8	94.9	26.96	26.5	7.6	38.8
302	13019220	Sour Moose Creek near Bondurant, WY	2.8	7,773.4	82.4	25.46	22.8	6.7	25.2
303	13019400	Cliff Creek near Bondurant, WY	58.2	8,078.6	71.6	28.09	35.1	17.7	55.5

Table 4. Basin and climatic characteristics for streamflow-gaging stations in Idaho and bordering States used in regional regression analysis--Continued

Map No.	Gaging station No.	Gaging station name	DA (mi^2)	E (ft)	F (percent)	P (in.)	BS (percent)	NF30 (percent)	S30 (percent)
		REGION 8--Continued							
304	13019438	Little Granite Creek at mouth near Bondurant, WY	82.7	8,559.5	54.5	31.02	38.6	16.1	60.8
305	13019500	Hoback River near Jackson, WY	561.3	7,961.5	60.9	26.68	30.3	12.7	42.6
306	13020000	Fall Creek near Jackson, WY	46.9	7,459.6	65.6	28.89	32.7	18.4	50.5
307	13021000	Cabin Creek near Jackson, WY	9.0	7,274.0	72.5	23.64	35.6	26.5	64.7
308	13022550	Red Creek near Alpine, WY	3.9	7,938.7	38.8	30.63	53.6	7.7	88.7
309	13023000	Greys River above reservoir, near Alpine, WY	448.8	8,105.3	72.2	34.91	35.1	16.7	54.5
310	13023800	Fish Creek near Smoot, WY	3.2	7,568.8	68.8	27.87	18.7	3.2	11.9
311	13024000	Salt River near Smoot, WY	48.2	8,010.1	73.4	32.89	28.0	9.3	40.5
312	13024500	Cottonwood Creek near Smoot, WY	25.7	8,647.5	73.4	39.48	45.1	21.6	81.3
313	13025000	Swift Creek near Afton, WY	27.7	8,496.0	72.3	39.33	49.3	20.7	84.9
314	13025500	Crow Creek near Fairview, WY	113.8	8,441.5	34.5	29.44	24.9	9.9	33.2
315	13027000	Strawberry Creek near Bedford, WY	20.1	8,469.4	54.0	40.81	49.7	20.1	80.7
316	13027200	Bear Canyon near Freedom, WY	3.3	7,087.4	50.8	28.44	27.9	4.5	40.2
317	13029500	McCoy Creek above reservoir near Alpine, WY	108.1	7,017.8	59.3	26.69	27.5	12.4	40.4
318	13030000	Indian Creek above reservoir near Alpine, WY	36.5	7,962.0	46.8	31.08	51.5	25.2	83.1
319	13030500	Elk Creek above reservoir near Irwin, ID	58.5	7,908.8	59.5	34.15	49.8	26.6	81.4
320	13032000	Bear Creek above reservoir near Irwin, ID	78.3	7,187.5	56.1	26.74	38.8	22.6	69.7
321	13038900	Targhee Creek near Macks Inn, ID	20.9	8,273.4	57.8	30.06	34.6	11.8	49.3
322	13044500	Warm River at Warm River, ID	131.1	6,675.6	69.3	31.78	9.1	1.5	5.5
323	13045500	Robinson Creek at Warm River, ID	123.7	6,418.3	65.4	35.26	10.6	1.3	5.4
324	13046680	Boundary Creek near Bechler Ranger Station Y.N.P., ID	85.4	7,912.5	87.7	56.03	6.9	0.2	3.3
325	13047500	Falls River near Squirrel, ID	333.6	7,540.3	83.6	52.87	11.0	2.4	7.8
326	13049500	Falls River near Chester, ID	512.9	6,974.2	63.3	42.64	9.9	2.1	6.4
327	13050700	Mail Cabin Creek near Victor, ID	3.0	8,287.6	77.8	40.89	45.1	37.0	86.6
328	13050800	Moose Creek near Victor, ID	21.8	8,499.6	65.1	54.17	41.7	23.4	68.3
329	13052200	Teton River above South Leigh Creek, near Driggs, ID	341.4	7,302.9	39.7	31.73	23.6	13.3	34.5
330	13054000	Teton River near Tetonia, ID	479.2	7,200.1	38.2	30.33	21.5	11.5	30.0
331	13054400	Milk Creek near Tetonia, ID	17.5	6,551.9	15.7	16.55	9.2	0.4	1.8
332	13055000	Teton River near St. Anthony, ID	874.8	6,920.9	36.1	27.65	19.0	9.1	24.3
333	13062700	Angus Creek near Henry, ID	14.3	6,881.2	28.3	20.00	18.0	5.3	18.2

Table 5. Peak flows at selected recurrence intervals for streamflow-gaging stations in Idaho and bordering States used in regional regression analysis

Map No.	Gaging station	Peak flow, in cubic feet per second, for given recurrence intervals, in years: 2	5	10	25	50	100	200	500	Period of known peak flows	Number of years of known peak
						REGION 1					
1	12305500	1,240	1,720	2,050	2,470	2,800	3,130	3,470	3,930	1929-80	50
2	12309000	42	89	134	210	284	373	482	661	1928-31, 33, 35-38, 74	11
3	12310800	154	241	317	439	550	682	838	1,090	1961-80	19
4	12311000	929	1,340	1,640	2,030	2,340	2,660	2,990	3,460	1928-74	45
5	12313500	524	886	1,180	1,630	2,020	2,460	2,950	3,710	1928-34, 72-79	15
6	12316800	338	426	477	534	573	610	644	686	1959-81	23
7	12320500	602	797	930	1,100	1,230	1,370	1,500	1,690	1928-59	32
8	12321000	1,930	2,520	2,890	3,340	3,670	3,990	4,300	4,710	1928-71	43
9	12392100	42	99	162	285	419	601	847	1,300	1962-81	20
10	12392155	3,140	3,770	4,180	4,700	5,080	5,460	5,850	6,370	1989-99	11
11	12392300	2,580	3,490	4,160	5,060	5,790	6,550	7,370	8,540	1959-82	24
12	12392800	36	44	49	54	58	61	64	68	1961-71	11
13	12393500	4,830	6,110	6,840	7,660	8,200	8,700	9,160	9,730	1913-48	35
14	12393600	64	99	124	157	183	209	237	276	1962-71	18
15	12396000	506	814	1,070	1,450	1,780	2,150	2,580	3,230	1951-97	47
16	12408500	298	458	563	693	786	877	966	1,080	1940-86	47
17	12409000	1,150	1,850	2,320	2,890	3,300	3,700	4,080	4,570	1923-97	75
18	12427000	109	134	150	171	186	201	216	236	1949-79	31
19	12429600	137	192	234	291	338	388	443	521	1962-75	14
20	12430370	22	60	105	191	285	410	576	875	1950, 62-75	15
21	12431000	1,290	1,970	2,460	3,100	3,590	4,090	4,610	5,320	1929-32, 47-97	55
						REGION 2					
22	12302500	642	969	1,230	1,600	1,920	2,270	2,660	3,250	1933, 37-44, 48, 54, 59-69, 74	23
23	12303100	226	319	385	474	544	617	693	801	1960-92	33
24	12303500	2,170	3,070	3,720	4,620	5,340	6,100	6,920	8,080	1945-57, 74, 83-96	28
25	12304250	27	42	54	70	84	98	114	137	1960-74	15
26	12304300	128	183	225	286	337	393	455	547	1960-78	19
27	12304400	170	244	293	355	401	448	494	557	1960-74	15
28	12341000	1,270	1,670	1,900	2,170	2,360	2,540	2,700	2,910	1899, 1948, 58-59, 61-64, 66-67	10

Table 5. Peak flows at selected recurrence intervals for streamflow-gaging stations in Idaho and bordering States used in regional regression analysis--Continued

Map No.	Gaging station	Peak flow, in cubic feet per second, for given recurrence intervals, in years: 2	5	10	25	50	100	200	500	Period of known peak flows	Number of years of known peak
						REGION 2--Continued					
29	12345800	148	209	247	293	326	357	388	427	1958-73	16
30	12347500	627	741	805	875	921	964	1,000	1,050	1947-69, 72	24
31	12350200	109	159	191	229	257	284	311	344	1958-73	16
32	12350500	810	1,060	1,200	1,370	1,490	1,600	1,700	1,830	1948-53, 58-73	22
33	12352000	1,670	2,110	2,360	2,660	2,850	3,040	3,210	3,420	1951-60, 72, 74	12
34	12353800	67	117	154	202	240	278	317	370	1961-79, 82	20
35	12353850	39	60	73	90	103	115	127	142	1961-75, 79	16
36	12354000	4,410	7,360	9,690	13,100	15,900	19,100	22,500	27,700	1911-17, 34, 48, 54, 59-75	27
37	12354100	180	238	273	314	342	369	394	426	1960-74	15
38	12389500	2,310	3,630	4,590	5,880	6,890	7,950	9,060	10,600	1948, 56-97	43
39	12390700	1,590	2,370	2,960	3,770	4,440	5,160	5,940	7,070	1956-97	42
40	12411000	6,040	9,280	11,600	14,700	17,100	19,600	22,300	25,900	1951-97	47
41	12413000	15,100	24,100	31,000	40,800	49,000	57,900	67,600	81,700	1940-97	58
42	12413100	104	142	168	201	225	250	275	309	1961-71, 73-80	19
43	12413140	376	674	919	1,290	1,600	1,960	2,350	2,940	1968-97	30
44	12413150	1,660	2,370	2,870	3,530	4,050	4,590	5,100	5,930	1968-88	21
45	12413200	73	121	159	212	256	303	355	429	1962-71	10
46	12413210	1,940	3,350	4,580	6,530	8,300	10,400	12,800	16,700	1987-99	13
47	12413470	3,660	6,240	8,370	11,600	14,300	17,500	21,000	26,400	1988-97	10
48	12413500	18,800	29,400	37,800	50,000	60,300	71,800	84,500	104,000	1911-97	66
49	12413700	587	936	1,230	1,700	2,120	2,610	3,190	4,100	1967-71, 73-81	14
50	12414500	15,500	22,300	26,900	32,900	37,500	42,200	47,000	53,600	1911-12, 21 -97	79
51	12414900	3,060	5,210	6,900	9,340	11,400	13,600	16,100	19,700	1966-97	32
52	12415000	4,780	8,090	11,000	15,600	19,800	24,800	30,700	40,100	1912, 21-66	45
53	12415100	113	161	199	253	299	350	407	492	1961-71, 74	12
54	12415200	67	97	119	149	172	196	222	258	1961-81	21
55	12416000	319	566	763	1,050	1,290	1,560	1,850	2,270	1948-97	43
56	13336500	25,500	33,000	37,700	43,300	47,400	51,400	55,300	60,400	1911, 30-99	71
57	13336600	73	114	143	180	208	236	265	304	1962-71	10

Table 5. Peak flows at selected recurrence intervals for streamflow-gaging stations in Idaho and bordering States used in regional regression analysis--Continued

Map No.	Gaging station	Peak flow, in cubic feet per second, for given recurrence intervals, in years: 2	5	10	25	50	100	200	500	Period of known peak flows	Number of years of known peak
						REGION 2--Continued					
58	13336650	78	106	124	145	161	176	190	210	1962-71	10
59	13336850	267	416	522	660	767	876	988	1,140	1962-71	10
60	13336900	1,710	2,030	2,220	2,440	2,600	2,750	2,890	3,080	1958-67	10
61	13337000	18,700	24,400	28,100	32,700	36,000	39,300	42,600	46,900	1911-12, 30-99	72
62	13340500	16,300	20,400	22,900	25,900	28,100	30,100	32,200	34,800	1945-69	25
63	13340600	18,800	25,000	29,200	34,600	38,700	42,900	47,100	52,900	1967-97	33
64	13341300	58	93	120	157	187	219	253	303	1960-71, 73-79	19
65	13341400	644	917	1,110	1,350	1,550	1,740	1,940	2,220	1960-71	12
						REGION 3					
66	12423550	55	120	171	240	293	346	400	469	1961-70, 72-76	16
67	12423700	25	33	37	42	45	48	51	54	1962-76	15
68	12423900	18	44	67	103	133	166	202	253	1954-73	20
69	12424000	6,510	10,600	13,300	16,600	19,000	21,400	23,700	26,600	1948-97	50
70	13334700	405	919	1,460	2,470	3,510	4,880	6,650	9,800	1960-82, 91-96	30
71	13335200	17	116	296	757	1,340	2,210	3,410	5,670	1959-76	18
72	13341100	47	108	166	260	346	447	564	746	1961-65, 67-71, 74-81	18
73	13341500	6,210	9,050	11,000	13,700	15,700	17,800	20,000	23,000	1945-71	26
74	13342450	816	1,890	2,910	4,580	6,120	7,940	10,000	13,300	1975-97	23
75	13343450	78	240	473	996	1,650	2,650	4,000	6,750	1963-77	15
76	13343800	651	1,310	1,890	2,760	3,530	4,380	5,340	6,780	1964-78	15
77	13344500	1,490	3,170	4,670	7,030	9,130	11,500	14,300	18,400	1915-17, 29-31, 59-90, 95-97	41
78	13344700	56	83	103	132	156	182	210	251	1961-71	11
79	13344800	799	1,300	1,690	2,260	2,750	3,280	3,870	4,750	1961-71, 74-81	19
80	13345000	3,580	5,800	7,470	9,800	11,700	13,700	15,800	18,900	1915-19, 67-97	36
81	13346100	4,530	6,820	8,480	10,800	12,600	14,500	16,500	19,400	1956-79	24
82	13346300	12	18	22	27	31	36	40	46	1956-59, 61, 63-64, 66-71	13
83	13346800	331	526	669	864	1,020	1,180	1,350	1,590	1979-97	19
84	13348000	1,040	1,840	2,520	3,590	4,550	5,660	6,950	8,960	1934-42, 48, 59-81	33
85	13348500	396	644	852	1,170	1,450	1,780	2,160	2,740	1935-40, 48, 60-79	27
86	13349210	5,600	8,980	11,600	15,200	18,200	21,400	24,800	29,800	1963-95	33

Table 5. Peak flows at selected recurrence intervals for streamflow-gaging stations in Idaho and bordering States used in regional regression analysis--Continued

Map No.	Gaging station	Peak flow, in cubic feet per second, for given recurrence intervals, in years: 2	5	10	25	50	100	200	500	Period of known peak flows	Number of years of known peak
						REGION 3--Continued					
87	13349400	1,840	3,680	5,350	8,040	10,500	13,500	16,900	22,300	1962-79	18
88	13350500	865	1,540	2,090	2,890	3,570	4,320	5,150	6,380	1954-79	26
89	14016000	522	1,080	1,560	2,310	2,970	3,720	4,560	5,820	1949-53, 55-67	18
90	14016500	858	1,500	2,050	2,910	3,670	4,560	5,590	7,200	1944-51, 56-68	21
91	14017000	2,770	4,430	5,660	7,380	8,760	10,200	11,800	14,100	1906-89	84
						REGION 4					
92	13185500	91	191	283	431	567	727	914	1,210	1914-18, 39-43, 55	11
93	13196500	13	24	34	47	59	72	87	108	1939-41, 51-71	24
94	13200000	1,650	2,880	3,790	5,020	5,980	6,970	7,980	9,380	1951-97	47
95	13200500	62	110	148	205	253	306	365	453	1951-71	21
96	13201000	1,930	3,080	3,930	5,080	5,990	6,950	7,950	9,360	1916-54	39
97	13207000	51	129	207	341	469	622	805	1,100	1955-59, 61-71	16
98	13207500	94	237	384	640	890	1,190	1,560	2,160	1955-68	14
99	13216500	882	1,620	2,240	3,170	3,960	4,850	5,830	7,310	1904-82, 84-94	90
100	13248900	78	136	185	262	332	413	508	658	1961-71, 73-80	19
101	13250600	938	1,430	1,770	2,210	2,550	2,900	3,250	3,720	1957, 62-82, 97	23
102	13250650	92	233	359	548	706	875	1,050	1,300	1962-71	10
103	13251300	39	58	73	92	107	123	139	163	1960-77	18
104	13251500	484	720	884	1,100	1,270	1,440	1,620	1,860	1937-71, 74-75, 97	38
105	13252500	55	65	71	78	82	86	90	95	1933-35, 37-43	10
106	13253500	991	1,540	1,940	2,490	2,920	3,380	3,870	4,555	1939-49, 56	12
107	13256000	2,910	4,290	5,260	6,550	7,550	8,590	9,660	11,200	1937-41, 43-53, 56	17
108	13257000	817	1,210	1,480	1,840	2,110	2,390	2,670	3,060	1911-13, 20-21, 37-49, 56, 81-82, 85-88, 97	26
109	13258500	4,770	7,090	8,590	10,400	11,700	13,000	14,300	15,900	1939-97	59
110	13260000	266	430	560	750	910	1,090	1,280	1,570	1939-62, 97	25
111	13261000	729	1,070	1,320	1,650	1,910	2,180	2,460	2,860	1923-27, 38-71, 97	40
112	13266000	9,720	15,200	19,000	23,600	27,100	30,500	33,800	38,200	1890-91, 1895-1904, 11-14, 53-97	61
113	13267000	420	655	831	1,080	1,270	1,490	1,710	2,040	1911-13, 19337-65	32
114	13267100	67	106	135	175	208	243	281	334	1962-71	10
115	13269300	686	931	1,080	1,260	1,390	1,520	1,640	1,790	1967-80	16
116	13270800	73	108	131	162	185	208	231	263	1964-81	18
117	13275500	708	1,060	1,290	1,570	1,780	1,980	2,170	2,430	1904-16, 20-25, 27-68	61
118	13288200	2,020	2,700	3,150	3,750	4,200	4,660	5,140	5,800	1958-97	40

Table 5. Peak flows at selected recurrence intervals for streamflow-gaging stations in Idaho and bordering States used in regional regression analysis--Continued

Map No.	Gaging station	Peak flow, in cubic feet per second, for given recurrence intervals, in years								Period of known peak flows	Number of years of known peak
		2	5	10	25	50	100	200	500		
						REGION 4--Continued					
119	13289100	89	137	169	211	242	273	303	345	1964-65, 67-81	17
120	13289600	91	167	226	311	380	454	532	642	1962-71	10
121	13289960	903	1,530	2,030	2,740	3,340	3,990	4,700	5,750	1979-96	18
122	13290190	2,570	4,140	5,310	6,920	8,210	9,570	11,000	13,000	1967-96	30
123	13291000	1,640	1,960	2,150	2,400	2,580	2,750	2,930	3,160	1945-53	9
124	13291200	72	103	123	150	169	189	209	236	1965-75	11
125	13315500	199	280	334	402	453	505	557	626	1937-38, 46-59, 62-71	26
126	13316500	4,900	6,710	7,900	9,390	10,500	11,600	12,700	14,100	1948, 51-99	48
127	13316800	138	218	282	373	449	533	625	761	1960-71	12
128	13317000	61,600	83,000	95,600	110,000	120,000	129,000	137,000	148,000	1894, 1911-99	88
129	13317200	98	208	309	468	612	779	970	1,270	1961-72	12
130	13319000	3,260	4,860	6,020	7,580	8,810	10,100	11,400	13,300	1904-09, 11-15, 18-23, 26-89	81
131	13320000	749	1,010	1,170	1,360	1,500	1,630	1,760	1,930	1912, 15, 18-19, 26, 97	75
132	13323600	405	545	637	753	840	926	1,010	1,130	1938-50	13
133	13329500	540	735	859	1,010	1,120	1,230	1,330	1,470	1915, 24-78	56
134	13330000	1,580	1,930	2,140	2,390	2,570	2,740	2,900	3,110	1913, 26-91, 95-97	70
135	13330500	923	1,220	1,400	1,630	1,800	1,960	2,120	2,330	1915, 24-85, 95-97	66
136	13331500	3,110	4,090	4,730	5,530	6,120	6,700	7,290	8,080	1913, 66-97	33
137	13337200	90	140	176	224	261	299	338	392	1962-71	10
138	13337500	1,930	2,600	3,060	3,650	4,100	4,560	5,030	5,680	1945-74	30
139	13337700	91	134	166	208	242	277	315	367	1962-81	16
140	13338000	5,000	6,770	8,030	9,700	11,000	12,400	13,800	15,900	1911-20, 23-63	51
141	13338200	186	249	291	341	378	415	451	499	1961-71	11
142	13338500	6,560	9,620	11,700	14,300	16,300	18,300	20,300	22,900	1964-99	36
143	13339000	53,000	67,800	76,800	87,400	94,900	102,000	109,000	118,000	1911-65	55
144	13339500	2,140	3,260	4,030	5,050	5,830	6,610	7,420	8,510	1980-99	20
145	13339700	123	174	207	251	283	316	349	394	1962-81	19
146	13339900	109	228	336	507	660	837	1,040	1,350	1962-71, 74-81	18
147	13340000	54,200	69,100	78,100	88,500	95,800	103,000	109,000	118,000	1931-33, 35-38, 65-99	42
148	14010000	776	1,180	1,510	1,970	2,370	2,810	3,300	4,040	1903, 07, 09-16, 32-91	70
149	14011000	489	812	1,080	1,490	1,840	2,250	2,710	3,420	1930, 33-69	38
150	14013000	890	1,550	2,120	3,010	3,810	4,740	5,830	7,540	1914-17, 40-97	62
151	14013500	317	548	730	991	1,210	1,440	1,700	2,070	1940-42, 44-71	31

Table 5. Peak flows at selected recurrence intervals for streamflow-gaging stations in Idaho and bordering States used in regional regression analysis--Continued

Map No.	Gaging station	Peak flow, in cubic feet per second, for given recurrence intervals, in years								Period of known peak flows	Number of years of known peak
		2	5	10	25	50	100	200	500		
						REGION 5					
152	12343400	2,340	3,260	3,830	4,510	5,000	5,460	5,900	6,470	1956-73	18
153	12346500	659	855	971	1,110	1,200	1,280	1,360	1,470	1948-54, 58-79	29
154	12351000	342	507	616	749	846	940	1,030	1,150	1920, 22-24, 38-73	40
155	12351400	51	73	88	106	119	131	144	159	1958-73	16
156	13135200	170	245	293	352	393	434	473	524	1962-71	10
157	13135500	905	1,250	1,470	1,740	1,940	2,130	2,310	2,560	1948-71	24
158	13135800	40	84	122	179	228	282	342	430	1962-71	10
159	13136500	495	656	758	882	972	1,060	1,150	1,260	1941-58	18
160	13139500	2,290	3,520	4,340	5,330	6,050	6,740	7,410	8,270	1915-97	83
161	13141000	1,660	2,760	3,460	4,270	4,820	5,330	5,790	6,350	1912-96	85
162	13141400	54	87	112	144	170	196	223	262	1961-72	11
163	13184200	332	454	526	611	668	722	773	837	1958, 63-71, 73-76, 78-80	17
164	13184800	102	149	182	224	256	289	323	369	1962-71	10
165	13185000	6,610	9,400	11,300	13,700	15,600	17,500	19,400	22,000	1871-72, 1911-99	91
166	13186000	4,400	6,050	7,010	8,110	8,840	9,510	10,100	10,900	1945-97	53
167	13186500	655	963	1,200	1,440	1,640	1,840	2,050	2,320	1946-56	11
168	13187000	513	709	845	1,030	1,170	1,310	1,470	1,680	1945-56	12
169	13234300	151	236	304	406	493	590	700	866	1962-71, 73-80	18
170	13235000	4,230	5,660	6,540	7,580	8,310	9,000	9,700	10,500	1941-99	59
171	13235100	148	241	312	412	495	584	681	821	1962-71	10
172	13237300	35	55	69	87	101	116	130	151	1962-71	10
173	13238300	346	436	493	563	614	664	714	780	1962-71	10
174	13240000	1,340	1,770	2,040	2,370	2,610	2,840	3,070	3,370	1946-97	52
175	13240500	1,280	1,750	2,050	2,400	2,700	2,900	3,130	3,440	1926-45	20
176	13245400	89	135	167	207	238	269	300	342	1962-71, 73-80	18
177	13292400	143	182	205	231	249	265	281	300	1963-71	9
178	13292500	517	643	716	800	858	913	964	1,030	1941-52	12
179	13293000	482	580	634	693	732	768	801	841	1941-52	12
180	13295000	1,000	1,360	1,570	1,830	2,010	2,180	2,340	2,540	1911-13, 21-74, 93-99	63
181	13295500	3,070	4,100	4,720	5,440	5,950	6,420	6,880	7,450	1926-60, 74	36
182	13296000	1,470	2,240	2,780	3,490	4,030	4,590	5,160	5,940	1921-49, 74	29
183	13296500	4,970	6,810	7,960	9,320	10,300	11,200	12,100	13,200	1922-91	70
184	13297100	33	60	82	113	138	164	192	232	1963-72	10
185	13308500	1,660	2,200	2,520	2,900	3,170	3,420	3,660	3,960	1929-72, 74	45

Table 5. Peak flows at selected recurrence intervals for streamflow-gaging stations in Idaho and bordering States used in regional regression analysis--Continued

Map No.	Gaging station	Peak flow, in cubic feet per second, for given recurrence intervals, in years								Period of known peak flows	Number of years of known peak
		2	5	10	25	50	100	200	500		
						REGION 5--Continued					
186	13309000	2,110	2,810	3,240	3,740	4,080	4,410	4,720	5,110	1922-60	39
187	13309220	8,870	12,600	15,100	18,300	20,600	23,000	25,400	28,500	1973-81	9
188	13310000	3,780	4,780	5,340	5,940	6,340	6,700	7,020	7,410	1945-58	14
189	13310500	1,030	1,330	1,510	1,710	1,850	1,980	2,110	2,270	1929, 31-60	31
190	13310700	3,330	4,620	5,450	6,460	7,200	7,920	8,620	9,550	1967-99	29
191	13311000	173	250	302	368	417	466	516	583	1929-42, 83-97	29
192	13311500	352	499	594	713	800	886	971	1,080	1929-40	12
193	13312000	953	1,270	1,470	1,720	1,910	2,090	2,270	2,510	1929-43	15
194	13313000	2,930	3,930	4,540	5,280	5,810	6,320	6,810	7,440	1929-99	71
195	13313500	1,400	1,780	2,010	2,280	2,470	2,650	2,830	3,050	1943-52	10
196	13314000	11,400	15,100	17,500	20,400	22,600	24,800	26,900	29,800	1932-48	13
197	13315000	61,500	75,100	82,600	91,000	96,500	101,000	106,000	112,000	1945-56	12
						REGION 6					
198	06013500	331	517	647	818	948	1,080	1,220	1,400	1946-53, 60-91	40
199	06015500	393	681	890	1,170	1,380	1,590	1,810	2,100	1921-32, 46-53, 55-58, 60-73, 75	39
200	06019500	968	1,350	1,630	1,990	2,270	2,570	2,880	3,310	1939-97	59
201	13108500	808	1,310	1,680	2,180	2,580	2,990	3,420	4,020	1937-53, 69-73	22
202	13112000	454	768	980	1,240	1,430	1,610	1,790	2,010	1925-97	73
203	13112900	9.8	17	23	32	39	47	55	66	1962-71	10
204	13113000	307	516	670	880	1,040	1,220	1,390	1,640	1941-52, 69-93	35
205	13113500	264	454	597	792	947	1,110	1,280	1,510	1921-73, 83-87	57
206	13117200	135	197	237	285	319	351	383	423	1962-71	10
207	13117300	379	522	611	717	793	866	937	1,030	1961-73	13
208	13120000	742	1,060	1,260	1,510	1,680	1,850	2,020	2,230	1944-97	54
209	13120500	2,150	3,000	3,490	4,050	4,430	4,780	5,100	5,490	1904-14, 20-97	89
210	13128900	183	228	254	286	308	330	350	377	1963-73, 80-84	16
211	13297300	8.9	15	20	26	32	37	43	51	1963-71, 74	10
212	13297330	123	240	332	461	565	675	790	950	1973-97	25
213	13297350	7.4	19	29	45	59	74	90	113	1971-97	27
214	13297355	252	469	630	845	1,010	1,180	1,340	1,570	1973-97	25
215	13297450	206	323	405	511	591	671	753	863	1970-86	17
216	13298000	1,590	2,330	2,810	3,400	3,820	4,230	4,630	5,140	1929-38, 73-81	19
217	13298300	85	245	422	744	1,070	1,480	1,980	2,820	1962-71	10
218	13299000	246	347	413	497	559	621	683	766	1944-63	20
219	13301700	147	206	243	288	321	353	384	424	1962-71, 73-76, 78-80	17

Table 5. Peak flows at selected recurrence intervals for streamflow-gaging stations in Idaho and bordering States used in regional regression analysis--Continued

Map No.	Gaging station	Peak flow, in cubic feet per second, for given recurrence intervals, in years								Period of known peak flows	Number of years of known peak
		2	5	10	25	50	100	200	500		
						REGION 6--Continued					
220	13301800	21	54	85	133	176	224	277	355	1962-71	10
221	13302500	8,490	12,200	14,500	17,200	19,000	20,800	22,500	24,600	1912-16, 20-97	83
222	13305000	910	1,450	1,810	2,260	2,580	2,900	3,210	3,610	1956-97	42
223	13305500	988	1,630	2,070	2,630	3,050	3,450	3,860	4,380	1929-43	15
224	13305700	97	164	212	277	327	379	431	504	1962-71	10
225	13305800	139	196	233	277	310	341	372	412	1962-80	19
226	13306000	556	744	862	1,000	1,100	1,200	1,300	1,420	1930-39	10
227	13306500	1,760	2,500	2,950	3,450	3,800	4,110	4,410	4,770	1945-77	33
228	13307000	13,500	18,200	21,000	24,200	26,400	28,400	30,400	32,800	1945-81	37
229	10315500	375	726	1,050	1,570	2,060	2,640	3,330	4,440	1943-80, 82-97	54
230	10329500	393	1,070	1,830	3,330	4,930	7,070	9,890	15,000	1922-27, 29-33, 35-97	74
231	10352500	454	1,210	1,950	3,200	4,340	5,680	7,220	9,580	1949-97	49
232	10353000	407	679	870	1,120	1,300	1,490	1,670	1,920	1949-81	33
233	10396000	1,380	2,270	2,890	3,670	4,250	4,820	5,390	6,130	1911-16, 18-21, 30, 38-98	72
234	10406500	111	190	252	340	413	491	575	696	1911, 22-23, 25-91	70
235	13155200	5.7	12	18	27	36	46	58	76	1960-71	12
236	13155300	87	151	207	294	374	467	577	751	1961-71, 73-80	19
						REGION 7a					
237	13161200	23	49	70	101	126	152	180	218	1963-79	17
238	13161300	188	400	587	878	1,130	1,420	1,750	2,240	1964-78	15
239	13162200	302	475	601	772	907	1,050	1,200	1,400	1963-78	16
240	13162400	81	173	256	385	500	630	778	1,000	1929-32, 54-71	22
241	13162500	444	622	738	882	989	1,090	1,200	1,340	1963-78	16
242	13162600	12	24	34	51	66	83	103	133	1939-49, 63, 66-97	44
243	13169500	165	573	1,030	1,830	2,590	3,470	4,490	6,020	1939-49	11
244	13170000	140	421	749	1,390	2,080	2,990	4,160	6,240	1961-71, 73-80	19
245	13170100	23	50	76	120	163	216	279	383	1961-71, 74-76, 78-80	17
246	13172200	43	149	291	603	975	1,510	2,260	3,720	1965-78	14
247	13172666	5.1	8.9	12	16	19	23	27	32	1963-93	31
248	13172668	4.2	6.6	8.3	10	12	13	15	16	1966-93	28
249	13172680	169	288	368	468	540	609	677	762	1964-90	27

Table 5. Peak flows at selected recurrence intervals for streamflow-gaging stations in Idaho and bordering States used in regional regression analysis--Continued

Map No.	Gaging station	Peak flow, in cubic feet per second, for given recurrence intervals, in years								Period of known peak flows	Number of years of known peak
		2	5	10	25	50	100	200	500		
						REGION 7a--Continued					
250	13172720	85	218	346	554	741	955	1,200	1,560	1964-93	30
251	13172735	63	191	331	580	823	1,120	1,470	2,030	1963-93	31
252	13172740	322	908	1,520	2,590	3,610	4,840	6,300	8,590	1961-71, 73-80	19
253	13172800	10	33	59	106	153	210	279	388	1946-52, 55-71	24
254	13178000	1,960	3,120	4,000	5,250	6,290	7,400	8,610	10,400	1961-80	19
255	13210300	59	175	299	514	720	966	1,250	1,710	1904-06, 10-17, 22-23, 38-62, 64-85	59
256	13226500	1,470	3,780	5,950	9,320	12,240	15,500	19,000	24,100	1963-79	17
						REGION 7b					
257	10119000	109	259	430	769	1,150	1,670	2,390	3,750	1912-13, 32, 41-69	32
258	10122500	65	110	145	194	235	279	327	396	1939-61	23
259	10123000	120	175	217	276	326	380	439	526	1941-43, 47-52	9
260	10172940	10	37	75	166	280	451	704	1,220	1959-73	15
261	13057600	208	318	393	488	559	629	699	792	1963-71	9
262	13057940	787	1,330	1,730	2,260	2,680	3,110	3,560	4,180	1978-79, 86-97	14
263	13073700	14	21	27	34	40	46	52	62	1961-71	11
264	13075000	298	445	566	750	911	1,100	1,310	1,640	1955-97	43
265	13075600	22	38	50	69	86	104	125	156	1961-1971	11
266	13076200	214	409	572	817	1,030	1,260	1,520	1,910	1985-94	10
267	13077700	69	109	141	188	228	274	325	402	1960-89	30
268	13079200	176	342	489	721	931	1,170	1,460	1,890	1957-67, 71	12
269	13083000	50	83	110	151	186	226	271	340	1911-16, 19-30, 32-97	84
270	13092000	200	329	415	520	596	668	738	826	1910-13, 39, 44-74	36
271	13145700	23	40	51	66	77	87	98	111	1961-76, 78-80	19
272	13147300	106	143	165	191	209	226	242	262	1963-71	9
273	13148000	880	1,410	1,800	2,330	2,750	3,190	3,660	4,300	1920-26, 41-58	25
						REGION 8					
274	06037500	1,360	1,710	1,930	2,200	2,390	2,570	2,750	2,990	1914-17, 19-73, 84-96	70
275	09223000	771	1,180	1,430	1,720	1,920	2,100	2,260	2,460	1953-98	46
276	10015700	335	706	1,060	1,660	2,230	2,930	3,770	5,160	1958-97	39
277	10040000	147	249	324	424	501	581	662	774	1940-51	12
278	10040500	165	294	386	506	595	684	772	887	1940-51	12
279	10041000	400	807	1,130	1,570	1,930	2,300	2,680	3,200	1950-92	43
280	10047500	99	140	166	199	222	246	269	299	1943-79	37

Table 5. Peak flows at selected recurrence intervals for streamflow-gaging stations in Idaho and bordering States used in regional regression analysis--Continued

Map No.	Gaging station	Peak flow, in cubic feet per second, for given recurrence intervals, in years								Period of known peak flows	Number of years of known peak
		2	5	10	25	50	100	200	500		
						REGION 8--Continued					
281	10058600	150	205	235	267	287	304	319	337	1961-86	26
282	10069000	50	69	82	101	117	133	151	177	1940-56	17
283	10072800	121	171	205	251	287	324	363	417	1961-86	26
284	10076400	73	108	129	153	169	183	196	212	1965-86	22
285	10077000	187	243	276	313	337	359	380	406	1914-17, 19-73, 84-96	70
286	10084500	372	561	691	861	990	1,120	1,260	1,440	1953-98	46
287	10089500	355	400	426	456	476	495	514	537	1958-97	39
288	10090800	45	96	138	198	248	301	357	434	1940-51	12
289	10093000	591	717	794	885	950	1,010	1,070	1,150	1940-51	12
290	10096000	558	624	660	702	730	756	780	810	1950-92	43
291	10099000	200	228	244	261	273	284	295	308	1943-79	37
292	13010000	5,360	6,100	6,460	6,800	7,010	7,180	7,330	7,500	1961-86	26
293	13010065	8,030	11,800	14,200	17,000	19,100	21,000	22,900	25,300	1940-56	17
294	13011500	2,510	3,350	3,830	4,360	4,710	5,030	5,320	5,670	1961-86	26
295	13011800	41	56	66	77	85	93	101	111	1965-86	22
296	13011900	4,080	4,970	5,510	6,180	6,650	7,110	7,560	8,150	1966-97	32
297	13012000	4,090	4,720	5,110	5,570	5,890	6,200	6,510	6,900	1918, 45-60	17
298	13014500	3,180	3,850	4,260	4,760	5,130	5,480	5,830	6,290	1958-97	39
299	13015000	2,700	3,890	4,700	5,740	6,530	7,330	8,140	9,250	1940-51	12
300	13018300	79	119	145	178	201	224	247	276	1940-51	12
301	13019210	13	17	18	20	21	22	23	24	1950-92	43
302	13019220	15	20	23	27	30	33	35	38	1943-79	37
303	13019400	612	837	982	1,160	1,290	1,420	1,550	1,720	1961-86	26
304	13019438	292	530	714	970	1,180	1,400	1,630	1,950	1940-56	17
305	13019500	3,750	4,780	5,440	6,240	6,830	7,410	7,980	8,740	1961-86	26
306	13020000	391	508	583	675	741	807	872	957	1965-86	22
307	13021000	128	164	184	206	221	234	247	262	1914-17, 19-73, 84-96	70
308	13022550	21	31	38	47	53	59	66	74	1953-98	46
309	13023000	3,290	4,410	5,100	5,900	6,450	6,980	7,480	8,120	1958-97	39
310	13023800	47	74	93	114	130	145	159	176	1940-51	12
311	13024000	250	334	386	446	489	529	568	617	1940-51	12
312	13024500	242	312	353	401	434	464	493	530	1950-92	43
313	13025000	505	623	693	776	834	890	943	1,010	1943-79	37
314	13025500	227	294	333	377	407	434	460	493	1961-86	26

Table 5. Peak flows at selected recurrence intervals for streamflow-gaging stations in Idaho and bordering States used in regional regression analysis--Continued

Map No.	Gaging station	Peak flow, in cubic feet per second, for given recurrence intervals, in years								Period of known peak flows	Number of years of known peak
		2	5	10	25	50	100	200	500		
						REGION 8--Continued					
315	13027000	263	320	353	390	416	439	462	490	1932-43	12
316	13027200	44	84	113	154	187	220	254	301	1961-71	11
317	13029500	924	1,200	1,360	1,550	1,670	1,790	1,900	2,030	1954-71, 74	19
318	13030000	200	255	288	326	353	377	401	431	1918, 54-71	19
319	13030500	464	591	666	751	810	864	916	981	1918, 1954-71	19
320	13032000	517	672	762	865	934	999	1,060	1,130	1918, 34-36, 54-71	22
321	13038900	258	327	368	416	449	480	509	547	1963-80	18
322	13044500	461	628	736	869	966	1,060	1,160	1,280	1912-14, 18-32	18
323	13045500	605	844	986	1,150	1,260	1,360	1,450	1,570	1912-14, 18-32	18
324	13046680	502	666	763	875	951	1,020	1,090	1,170	1984-97	14
325	13047500	3,550	4,480	5,060	5,760	6,270	6,770	7,260	7,900	1905-09, 18-97	85
326	13049500	3,540	4,560	5,210	6,020	6,620	7,210	7,800	8,580	1920-97	78
327	13050700	38	51	59	70	77	85	92	102	1962-71	10
328	13050800	280	338	371	408	433	456	478	504	1962-71	10
329	13052200	1,460	1,920	2,200	2,530	2,760	2,980	3,200	3,470	1962-97	36
330	13054000	1,270	1,710	1,990	2,320	2,560	2,780	3,000	3,280	1930-32, 34, 40-57	22
331	13054400	84	254	445	802	1,170	1,620	2,190	3,150	1962-80	19
332	13055000	3,380	4,610	5,420	6,450	7,210	7,970	8,750	9,780	1890-93, 1903-09, 20-97	88
333	13062700	283	516	701	968	1,190	1,430	1,680	2,060	1963-71, 74-80	16

Table 9. $(X^T \Lambda^{-1} X)^{-1}$ matrices for the T-year (T = 2, 5, 10, 25, 50, 100, 200, and 500) regional regression equations for Idaho

[Some numbers are in scientific notation; DA, drainage area; E, mean basin elevation; F, percentage of forest cover in the basin; P, mean annual precipitation; NF30, percentage of north-facing slopes greater than 30 percent; BS, average basin slope; S30, percentage of slopes greater than 30 percent]

$(X^T \Lambda^{-1} X)^{-1}$ matrix

REGION 1

CONSTANT	DA	E	F
2-year recurrence interval			
0.70947	-0.13937E-01	0.74767E-01	-0.38336
-0.13937E-01	0.50165E-02	0.20736E-02	0.22620E-02
0.74767E-01	0.20736E-02	0.26166	-0.11881
-0.38336	0.22620E-02	-0.11881	0.23590
5-year recurrence interval			
0.56929	-0.13099E-01	0.42010E-01	-0.29924
-0.13099E-01	0.36470E-02	0.19558E-02	0.29579E-02
0.42010E-01	0.19558E-02	0.18097	-0.77605E-01
-0.29924	0.29579E-02	-0.77605E-01	0.17800
10-year recurrence interval			
0.58339	-0.14658E-01	0.30779E-01	-0.30104
-0.14658E-01	0.34412E-02	0.21476E-02	0.38258E-02
0.30779E-01	0.21476E-02	0.16433	-0.66963E-01
-0.30104	0.38258E-02	-0.66963E-01	0.17462
25-year recurrence interval			
0.67266	-0.18001E-01	0.24555E-01	-0.34210
-0.18001E-01	0.36737E-02	0.25408E-02	0.51651E-02
0.24555E-01	0.25408E-02	0.16945	-0.65577E-01
-0.34210	0.51651E-02	-0.65577E-01	0.19420
50-year recurrence interval			
0.77568	-0.21203E-01	0.23830E-01	-0.39246
-0.21203E-01	0.40965E-02	0.29094E-02	0.62941E-02
0.23830E-01	0.29094E-02	0.18638	-0.70549E-01
-0.39246	0.62941E-02	-0.70549E-01	0.22091
100-year recurrence interval			
0.90234	-0.24874E-01	0.25410E-01	-0.45552
-0.24874E-01	0.46760E-02	0.33256E-02	0.75159E-02
0.25410E-01	0.33256E-02	0.21144	-0.79177E-01
-0.45552	0.75159E-02	-0.79177E-01	0.25532
200-year recurrence interval			
1.0492	-0.28955E-01	0.28796E-01	-0.52941
-0.28955E-01	0.53858E-02	0.37810E-02	0.88248E-02
0.28796E-01	0.37810E-02	0.24315	-0.90760E-01
-0.52941	0.88248E-02	-0.90760E-01	0.29625
500-year recurrence interval			
1.2708	-0.34905E-01	0.35617E-01	-0.64167
-0.34905E-01	0.64979E-02	0.44322E-02	0.10677E-01
0.35617E-01	0.44322E-02	0.29391	-0.10996
-0.64167	0.10677E-01	-0.10996	0.35911

Table 9. $(X^T \Lambda^{-1} X)^{-1}$ matrices for the T-year (T = 2, 5, 10, 25, 50, 100, 200, and 500) regional regression equations for Idaho—Continued

$(X^T \Lambda^{-1} X)^{-1}$ matrix

REGION 2

CONSTANT	DA	E	P
2-year recurrence interval			
0.39901	0.98739E-03	0.72212E-01	-0.27258
0.98739E-03	0.13325E-02	0.30477E-02	-0.32694E-02
0.72212E-01	0.30477E-02	0.25340	-0.14973
-0.27258	-0.32694E-02	-0.14973	0.23015
5-year recurrence interval			
0.40948	0.75032E-03	0.70109E-01	-0.27767
0.75032E-03	0.13652E-02	0.32756E-02	-0.32653E-02
0.70109E-01	0.32756E-02	0.26226	-0.15266
-0.27767	-0.32653E-02	-0.15266	0.23452
10-year recurrence interval			
0.43572	0.58300E-03	0.71219E-01	-0.29374
0.58300E-03	0.14491E-02	0.35727E-02	-0.33884E-02
0.71219E-01	0.35727E-02	0.28123	-0.16164
-0.29374	-0.33884E-02	-0.16164	0.24816
25-year recurrence interval			
0.48030	0.37791E-03	0.74431E-01	-0.32172
0.37791E-03	0.15910E-02	0.40229E-02	-0.36188E-02
0.74431E-01	0.40229E-02	0.31249	-0.17716
-0.32172	-0.36188E-02	-0.17716	0.27185
50-year recurrence interval			
0.51875	0.23295E-03	0.77775E-01	-0.34614
0.23295E-03	0.17127E-02	0.43888E-02	-0.38254E-02
0.77775E-01	0.43888E-02	0.33895	-0.19062
-0.34614	-0.38254E-02	-0.19062	0.29249
100-year recurrence interval			
0.56026	0.95155E-04	0.81735E-01	-0.37268
0.95155E-04	0.18437E-02	0.47711E-02	-0.40529E-02
0.81735E-01	0.47711E-02	0.36719	-0.20520
-0.37268	-0.40529E-02	-0.20520	0.31490
200-year recurrence interval			
0.60440	-0.36634E-04	0.86222E-01	-0.40104
-0.36634E-04	0.19825E-02	0.51679E-02	-0.42981E-02
0.86222E-01	0.51679E-02	0.39694	-0.22073
-0.40104	-0.42981E-02	-0.22073	0.33883
500-year recurrence interval			
0.66637	-0.20300E-03	0.92873E-01	-0.44102
-0.20300E-03	0.21769E-02	0.57136E-02	-0.46470E-02
0.92873E-01	0.57136E-02	0.43836	-0.24258
-0.44102	-0.46470E-02	-0.24258	0.37254

Table 9. $(X^T \Lambda^{-1} X)^{-1}$ matrices for the T-year (T = 2, 5, 10, 25, 50, 100, 200, and 500) regional regression equations for Idaho—Continued

$(X^T \Lambda^{-1} X)^{-1}$ matrix

REGION 3

CONSTANT	DA	E
2-year recurrence interval		
0.72994E-01	-0.40438E-02	-0.13200
-0.40438E-02	0.31745E-02	-0.38284E-02
-0.13200	-0.38284E-02	0.29798
5-year recurrence interval		
0.49599E-01	-0.26739E-02	-0.86950E-01
-0.26739E-02	0.18477E-02	-0.17835E-02
-0.86950E-01	-0.17835E-02	0.18907
10-year recurrence interval		
0.47622E-01	-0.25401E-02	-0.82140E-01
-0.25401E-02	0.16155E-02	-0.12690E-02
-0.82140E-01	-0.12690E-02	0.17493
25-year recurrence interval		
0.51762E-01	-0.27416E-02	-0.88365E-01
-0.27416E-02	0.16452E-02	-0.10704E-02
-0.88365E-01	-0.10704E-02	0.18572
50-year recurrence interval		
0.57529E-01	-0.30306E-02	-0.97974E-01
-0.30306E-02	0.17899E-02	-0.10973E-02
-0.97974E-01	-0.10973E-02	0.20523
100-year recurrence interval		
0.64774E-01	-0.33881E-02	-0.11036
-0.33881E-02	0.20002E-02	-0.12259E-02
-0.11036	-0.12259E-02	0.23114
200-year recurrence interval		
0.73334E-01	-0.38016E-02	-0.12523
-0.38016E-02	0.22687E-02	-0.14516E-02
-0.12523	-0.14516E-02	0.26285
500-year recurrence interval		
0.86049E-01	-0.44010E-02	-0.14759
-0.44010E-02	0.26877E-02	-0.18708E-02
-0.14759	-0.18708E-02	0.31114

Table 9. $(X^T \Lambda^{-1} X)^{-1}$ matrices for the T-year (T = 2, 5, 10, 25, 50, 100, 200, and 500) regional regression equations for Idaho—Continued

$(X^T \Lambda^{-1} X)^{-1}$ matrix

REGION 4

	CONSTANT	DA	E
2-year recurrence interval			
	0.76068E-01	-0.75066E-03	-0.10719
	-0.75066E-03	0.17192E-02	-0.36670E-02
	-0.10719	-0.36670E-02	0.16698
5-year recurrence interval			
	0.60600E-01	-0.76276E-03	-0.84468E-01
	-0.76276E-03	0.13324E-02	-0.26384E-02
	-0.84468E-01	-0.26384E-02	0.13046
10-year recurrence interval			
	0.56593E-01	-0.82946E-03	-0.78182E-01
	-0.82946E-03	0.12090E-02	-0.22437E-02
	-0.78182E-01	-0.22437E-02	0.11985
25-year recurrence interval			
	0.55279E-01	-0.93740E-03	-0.75557E-01
	-0.93740E-03	0.11357E-02	-0.19384E-02
	-0.75557E-01	-0.19384E-02	0.11475
50-year recurrence interval			
	0.55980E-01	-0.10258E-02	-0.75999E-01
	-0.10258E-02	0.11190E-02	-0.18033E-02
	-0.75999E-01	-0.18033E-02	0.11471
100-year recurrence interval			
	0.57609E-01	-0.11181E-02	-0.77771E-01
	-0.11181E-02	0.11239E-02	-0.17209E-02
	-0.77771E-01	-0.17209E-02	0.11678
200-year recurrence interval			
	0.59915E-01	-0.12138E-02	-0.80509E-01
	-0.12138E-02	0.11445E-02	-0.16761E-02
	-0.80509E-01	-0.16761E-02	0.12037
500-year recurrence interval			
	0.63756E-01	-0.13453E-02	-0.85259E-01
	-0.13453E-02	0.11901E-02	-0.16596E-02
	-0.85259E-01	-0.16596E-02	0.12688

Table 9. $(X^T \Lambda^{-1} X)^{-1}$ matrices for the T-year (T = 2, 5, 10, 25, 50, 100, 200, and 500) regional regression equations for Idaho—Continued

$(X^T \Lambda^{-1} X)^{-1}$ matrix

REGION 5

CONSTANT	DA	P	NF30
2-year recurrence interval			
0.27767	-0.62717E-02	-0.15755	-0.21191E-01
-0.62717E-02	0.15842E-02	0.33900E-02	-0.17302E-02
-0.15755	0.33900E-02	0.98903E-01	0.12712E-02
-0.21191E-01	-0.17302E-02	0.12712E-02	0.18410E-01
5-year recurrence interval			
0.26636	-0.65343E-02	-0.15078	-0.19510E-01
-0.65343E-02	0.15652E-02	0.35123E-02	-0.16736E-02
-0.15078	0.35123E-02	0.94362E-01	0.94276E-03
-0.19510E-01	-0.16736E-02	0.94276E-03	0.17377E-01
10-year recurrence interval			
0.27539	-0.72395E-02	-0.15568	-0.19203E-01
-0.72395E-02	0.16639E-02	0.38862E-02	-0.17632E-02
-0.15568	0.38862E-02	0.97206E-01	0.60777E-03
-0.19203E-01	-0.17632E-02	0.60777E-03	0.17717E-01
25-year recurrence interval			
0.29496	-0.83118E-02	-0.16653	-0.19363E-01
-0.83118E-02	0.18324E-02	0.44586E-02	-0.19283E-02
-0.16653	0.44586E-02	0.10373	0.18438E-03
-0.19363E-01	-0.19283E-02	0.18438E-03	0.18681E-01
50-year recurrence interval			
0.31294	-0.91632E-02	-0.17655	-0.19762E-01
-0.91632E-02	0.19733E-02	0.49139E-02	-0.20698E-02
-0.17655	0.49139E-02	0.10982	-0.11140E-03
-0.19762E-01	-0.20698E-02	-0.11140E-03	0.19632E-01
100-year recurrence interval			
0.33276	-0.10035E-01	-0.18763	-0.20337E-01
-0.10035E-01	0.21217E-02	0.53802E-02	-0.22203E-02
-0.18763	0.53802E-02	0.11659	-0.38839E-03
-0.20337E-01	-0.22203E-02	-0.38839E-03	0.20716E-01
200-year recurrence interval			
0.35403	-0.10924E-01	-0.19954	-0.21051E-01
-0.10924E-01	0.22763E-02	0.58558E-02	-0.23778E-02
-0.19954	0.58558E-02	0.12389	-0.64991E-03
-0.21051E-01	-0.23778E-02	-0.64991E-03	0.21904E-01
500-year recurrence interval			
0.38398	-0.12124E-01	-0.21633	-0.22174E-01
-0.12124E-01	0.24889E-02	0.64978E-02	-0.25949E-02
-0.21633	0.64978E-02	0.13421	-0.97656E-03
-0.22174E-01	-0.25949E-02	-0.97656E-03	0.23608E-01

Table 9. $(X^T \Lambda^{-1} X)^{-1}$ matrices for the T-year (T = 2, 5, 10, 25, 50, 100, 200, and 500) regional regression equations for Idaho—Continued

$(X^T \Lambda^{-1} X)^{-1}$ matrix

REGION 6

CONSTANT	DA	P
2-year recurrence interval		
0.73182	-0.19589E-01	-0.50715
-0.19589E-01	0.32568E-02	0.93413E-02
-0.50715	0.93413E-02	0.35932
5-year recurrence interval		
0.64178	-0.17889E-01	-0.44309
-0.17889E-01	0.28998E-02	0.85868E-02
-0.44309	0.85868E-02	0.31296
10-year recurrence interval		
0.64897	-0.18653E-01	-0.44665
-0.18653E-01	0.29679E-02	0.89884E-02
-0.44665	0.89884E-02	0.31468
25-year recurrence interval		
0.68723	-0.20406E-01	-0.47131
-0.20406E-01	0.31852E-02	0.98667E-02
-0.47131	0.98667E-02	0.33111
50-year recurrence interval		
0.72572	-0.21964E-01	-0.49663
-0.21964E-01	0.33910E-02	0.10638E-01
-0.49663	0.10638E-01	0.34829
100-year recurrence interval		
0.76837	-0.23615E-01	-0.52486
-0.23615E-01	0.36143E-02	0.11450E-01
-0.52486	0.11450E-01	0.36756
200-year recurrence interval		
0.81351	-0.25317E-01	-0.55485
-0.25317E-01	0.38479E-02	0.12286E-01
-0.55485	0.12286E-01	0.38810
500-year recurrence interval		
0.87556	-0.27612E-01	-0.59621
-0.27612E-01	0.41662E-02	0.13411E-01
-0.59621	0.13411E-01	0.41650

Table 9. $(X^T \Lambda^{-1} X)^{-1}$ matrices for the T-year (T = 2, 5, 10, 25, 50, 100, 200, and 500) regional regression equations for Idaho—Continued

$(X^T \Lambda^{-1} X)^{-1}$ matrix

REGION 7a

CONSTANT	DA	E
2-year recurrence interval		
0.27535	-0.10043E-01	-0.32931
-0.10043E-01	0.29644E-02	0.69738E-02
-0.32931	0.69738E-02	0.40923
5-year recurrence interval		
0.23543	-0.88447E-02	-0.27938
-0.88447E-02	0.22933E-02	0.66030E-02
-0.27938	0.66030E-02	0.34388
10-year recurrence interval		
0.24212	-0.92360E-02	-0.28606
-0.92360E-02	0.21875E-02	0.71983E-02
-0.28606	0.71983E-02	0.35006
25-year recurrence interval		
0.26803	-0.10339E-01	-0.31562
-0.10339E-01	0.22544E-02	0.83448E-02
-0.31562	0.83448E-02	0.38440
50-year recurrence interval		
0.29504	-0.11429E-01	-0.34698
-0.11429E-01	0.23961E-02	0.93703E-02
-0.34698	0.93703E-02	0.42175
100-year recurrence interval		
0.32653	-0.12680E-01	-0.38378
-0.12680E-01	0.25920E-02	0.10499E-01
-0.38378	0.10499E-01	0.46596
200-year recurrence interval		
0.36169	-0.14066E-01	-0.42502
-0.14066E-01	0.28316E-02	0.11719E-01
-0.42502	0.11719E-01	0.51577
500-year recurrence interval		
0.41302	-0.16081E-01	-0.48542
-0.16081E-01	0.32057E-02	0.13456E-01
-0.48542	0.13456E-01	0.58902

Table 9. $(X^T \Lambda^{-1} X)^{-1}$ matrices for the T-year (T = 2, 5, 10, 25, 50, 100, 200, and 500) regional regression equations for Idaho—Continued

$(X^T \Lambda^{-1} X)^{-1}$ matrix

REGION 7b

	CONSTANT	DA
2-year recurrence interval		
	0.52959E-01	-0.27639E-01
	-0.27639E-01	0.17103E-01
5-year recurrence interval		
	0.35447E-01	-0.18388E-01
	-0.18388E-01	0.11360E-01
10-year recurrence interval		
	0.28742E-01	-0.14817E-01
	-0.14817E-01	0.91404E-02
25-year recurrence interval		
	0.24078E-01	-0.12308E-01
	-0.12308E-01	0.75821E-02
50-year recurrence interval		
	0.22709E-01	-0.11549E-01
	-0.11549E-01	0.71136E-02
100-year recurrence interval		
	0.22745E-01	-0.11530E-01
	-0.11530E-01	0.71060E-02
200-year recurrence interval		
	0.23947E-01	-0.12122E-01
	-0.12122E-01	0.74783E-02
500-year recurrence interval		
	0.27094E-01	-0.13718E-01
	-0.13718E-01	0.84751E-02

Table 9. $(X^T \Lambda^{-1} X)^{-1}$ matrices for the T-year (T = 2, 5, 10, 25, 50, 100, 200, and 500) regional regression equations for Idaho—Continued

$(X^T \Lambda^{-1} X)^{-1}$ matrix			
REGION 8			
CONSTANT	**DA**	**P**	**S30**
2-year recurrence interval			
0.13509	-0.10754E-01	-0.17622	0.87079E-01
-0.10754E-01	0.29289E-02	0.75498E-02	-0.32850E-02
-0.17622	0.75498E-02	0.30082	-0.17123
0.87079E-01	-0.32850E-02	-0.17123	0.10528
5-year recurrence interval			
0.11982	-0.95381E-02	-0.15664	0.77537E-01
-0.95381E-02	0.26072E-02	0.66765E-02	-0.29116E-02
-0.15664	0.66765E-02	0.26855	-0.15317
0.77537E-01	-0.29116E-02	-0.15317	0.94356E-01
10-year recurrence interval			
0.11788	-0.94019E-02	-0.15429	0.76478E-01
-0.94019E-02	0.25782E-02	0.65545E-02	-0.28648E-02
-0.15429	0.65545E-02	0.26551	-0.15173
0.76478E-01	-0.28648E-02	-0.15173	0.93636E-01
25-year recurrence interval			
0.11957	-0.95651E-02	-0.15673	0.77832E-01
-0.95651E-02	0.26337E-02	0.66320E-02	-0.29078E-02
-0.15673	0.66320E-02	0.27107	-0.15530
0.77832E-01	-0.29078E-02	-0.15530	0.96081E-01
50-year recurrence interval			
0.12248	-0.98191E-02	-0.16072	0.79924E-01
-0.98191E-02	0.27113E-02	0.67827E-02	-0.29807E-02
-0.16072	0.67827E-02	0.27900	-0.16015
0.79924E-01	-0.29807E-02	-0.16015	0.99257E-01
100-year recurrence interval			
0.12621	-0.10138E-01	-0.16580	0.82561E-01
-0.10138E-01	0.28066E-02	0.69799E-02	-0.30741E-02
-0.16580	0.69799E-02	0.28883	-0.16609
0.82561E-01	-0.30741E-02	-0.16609	0.10311
200-year recurrence interval			
0.13049	-0.10500E-01	-0.17161	0.85568E-01
-0.10500E-01	0.29136E-02	0.72086E-02	-0.31814E-02
-0.17161	0.72086E-02	0.29995	-0.17277
0.85568E-01	-0.31814E-02	-0.17277	0.10744
500-year recurrence interval			
0.13677	-0.11027E-01	-0.18014	0.89964E-01
-0.11027E-01	0.30682E-02	0.75464E-02	-0.33391E-02
-0.18014	0.75464E-02	0.31613	-0.18247
0.89964E-01	-0.33391E-02	-0.18247	0.11368

B.40.02 Magnitude and Frequency of Floods in Small Drainage Basins in Idaho by U.S. Geological Survey; Water-Resource Investigations 7-73. The following is a portion of this report. The report was modified for ITD projects with forest cover between 0 and 30 percent. It was discovered that abnormally high results were obtained for watersheds with a low percentage of forest cover. Details are shown in Table B-1. The revision was reviewed and concurred with by L. C. Kjelstrom and W. A. Harenberg of the U.S. Geological Survey. Minor changes have been made in the text for consistency.

A design method to determine the magnitude and frequency of floods in small drainage basins in Idaho has been compiled by the U.S. Department of the Interior, Geological Survey, in cooperation with the Idaho Transportation Department, Idaho Department of Water Administration, and the U.S. Forest Service.

Authors and compilers of this report are C. A. Thomas, W. A. Harenberg, and J. M. Anderson.

Introduction to Flood Design Method

This report describes a method for estimating peak discharges at 10-, 25-, and 50-year recurrence intervals for most small streams in Idaho. Reliable estimates can be obtained using this method, but there are significant limitations and variations that should be considered.

The method of estimating peak discharges developed for this report is for sites on streams with natural flow. Therefore, for sites on regulated streams, the effect of the regulation must be superimposed on results obtained from the method described herein. Regulation may be caused either by works of man or by interaction with groundwater systems. Estimates of peak discharge may be poor for streams draining basins on or flowing across extensive areas of deep, coarse alluvium, or lava flows; for streams whose basins are urbanized; for streams draining irrigated agricultural lands; and for streams draining basins having less than about 30 percent forest cover. Computed flows in those parts of the state subject to recurrent high-intensity thunderstorms over small areas may be too low to be acceptable as reasonable estimates. Some anomalous areas have been identified where the method developed does not apply. A determination of peak discharge should not be considered complete until an assessment of the limitation has been made.

Table B-1

SUMMARY OF REGRESSION EQUATIONS BY REGION FOR PEAK DISCHARGES IN IDAHO (Final Q Values Obtained From the Regression Equations Should be Converted From cfs to m^3/s).

Region	Regression Equation for Q10	Value of Exponent n	Standard Error of Estimate (percent)	Q25/Q10 Ratio	Q50/Q10 Ratio
1	$Q10 = 49.8\ A^{0.862}$		41	1.3	1.5
2	$Q10 = 66.5\ A^{0.801}$(Forest Factor)	-0.236	61	1.3	1.5
3	$Q10 = 3.81\ A^{0.875}$(Forest Factor) $N^{2.02}$	-0.216	51	1.3	1.5
4	$Q10 = 43.4\ A^{0.857}$(Forest Factor)	-0.210	62	1.4	1.8
5	$Q10 = 13.0\ A^{0.918}$		61	1.3	1.5
6	$Q10 = 188\ A^{0.873} La^{0.773}\ N^{-1.82}$		41	1.2	1.3
7	$Q10 = 20.6\ A^{0.806} W^{-1.05}$		59	1.2	1.4
8	$Q10 = 193\ A^{0.758}$(Forest Factor) $N^{-4.25}$		45	1.4	1.7

EXPLANATION:

A	=	Drainage area in square miles (0.5 – 200 mi^2).
F	=	Percentage of forest cover plus 1 percent.
La	=	Percentage of area of lakes and ponds on the basin plus 1 percent.
N	=	Latitude of centroid of basin in degrees minus 40 degrees.
W	=	Longitude of centroid of basin in degrees minus 110 degrees.

MODIFICATION FOR USE ON ITD PROJECTS

The Forest Factor, F^n, has been modified in the appropriate equations as follows:

PERCENT FOREST 0 TO 30	PERCENT FOREST 30 TO 100
$\text{Forest Factor} = \dfrac{(31 - F)(30^n - 32^n)}{2} + 31^n$	$\text{Forest Factor} = F^n$

Where
n = exponent of F in each applicable regional equation.

Design Method

Subject to the limitations outlined in the section on UNDEFINED AREAS WHERE REGRESSION RELATIONS DO NOT APPLY, peak discharges at selected recurrence intervals can be determined for small streams as follows:

1. Locate the site on the map of Figure B-9 (pages 1, 2, and 3) and determine if a gage has been operated nearby on the same stream. An explanation of the gaging-station-numbering system used by the U.S. Geological Survey is included later and, for convenience, also on Figure B-9.

If a gage site is located nearby on the same stream and the basin characteristics above the gaged and ungaged sites are relatively homogenous, check Table B-1 for peak discharge at the desired recurrence interval at the gaged site and adjust the peak to the ungaged site on the basis of drainage area. If the stream has not been gaged nearby, inspect Figure B-9 to determine if the basin is outside the undefined areas and, if so, determine in which region the site is located.

2. By inspection of the applicable regression equation in Table B-1, determine which basin characteristics are needed. A description of the equation symbols and methods of determining the basin characteristics are shown below.

3. Determine the required basin characteristics from the best available topographic map. A U.S. Geological Survey 7-1/2-minute topographic map is suggested. Complete coverage of the state is available in the U.S. Geological Survey 1:250,000 scale map series. Determine the forest cover (F) that is needed for evaluation purposes, even though it may not appear in the equation.

4. Having determined the basin characteristics, use the regression equations from Table D-1 to compute the peak discharges at 10-, 25-, and 50-year recurrence intervals.

Regression equations are valid for drainage basins from 0.5 to 200 square miles (1.3 to 518 square kilometers).

5. Investigate further to determine if limitations apply that invalidate the use of the regression equation or if adjustments to the discharge should be made that would improve the design discharge. Check peak discharges for reasonableness by comparing with peak discharges of record for nearby streams (see examples).

Gaging-Station-Numbering System

Each gaging station and partial-record station has been assigned a number in downstream order in accordance with the permanent numbering system used by the Geological Survey. Numbers are assigned in a downstream direction along the main stream, and stations on tributaries between main-stream stations are numbered in the order they enter the main stream. A similar order is followed on other ranks of tributaries. The complete 8-digit number, such as 13038900 includes the part number "13" plus a 6-digit station number. Only the 6-digit station number is shown in this illustration.

Summary of regression equations by region for peak discharges in Idaho.

Region	Regression equation for Q_{10}	Standard error of estimate (percent)	Q_{25}/Q_{10} ratio	Q_{50}/Q_{10} ratio
1	$Q_{10} = 49.8\ A^{0.862}$	41	1.3	1.5
2	$Q_{10} = 66.5\ A^{0.801}F^{-0.236}$	61	1.3	1.5
3	$Q_{10} = 3.81\ A^{0.875}F^{-0.216}N^{2.02}$	51	1.3	1.5
4	$Q_{10} = 43.4\ A^{0.857}F^{-0.210}$	62	1.4	1.8
5	$Q_{10} = 13.0\ A^{0.918}$	61	1.3	1.5
6	$Q_{10} = 188\ A^{0.873}La^{0.773}N^{-1.82}$	41	1.2	1.3
7	$Q_{10} = 20.6\ A^{0.806}W^{-1.05}$	59	1.2	1.4
8	$Q_{10} = 193\ A^{0.758}F^{0.222}N^{-4.25}$	45	1.4	1.7

EXPLANATION

A = Drainage area in square miles.
F = Percentage of forest cover plus 1 percent.
La = Percentage of area of lakes and ponds on the basin plus 1 percent.
N = Latitude of centroid of basin in degrees minus 40 degrees.
W = Longitude of centroid of basin in degrees minus 110 degrees.

EXPLANATION

Part 13
River basin boundary and number

Region boundary

4
Region number

Boundary of undefined area (hatchered area)

Known gaining stream reach

Known losing stream reach

Irrigated area

Gaging stations

128900
Active station and number

303000
Discontinued station and number

317200
Active crest-stage station and number

312000
Discontinued crest-stage station and number

172666
Active station and number operated by Agricultural Research Service

Parts and numbers are those permanently assigned in Geological Survey system and used in this report.

FIGURE 1.--MAP OF IDAHO SHOWING LOCATIONS OF GAGING STATIONS USED IN THE ANALYSES, REGIONS, AND SOME AREAS AND STREAMS FOR WHICH REGRESSION EQUATIONS DO NOT APPLY.

Table B-2

DRAINAGE AREAS, FLOOD DISCHARGES AT SELECTED FREQUENCIES, AND MAXIMUM FLOWS OF RECORD FOR STREAMS DRAINING LESS THAN 50 SQUARE MILES WITH 8 YEARS OR MORE OF RECORD

Station No.	Station Name	Drainage Area (square miles)	Discharge (cfs) Recurrence Interval (years) 2	5	10	20	25	50	Maximum of Record
			Missouri River Basin						
06011900	Red Rock River Trib.	1.0	4.2	8.7	15	21	-	-	15
			Bear River Basin						
10040000	Thomas Fork	45.3	147	262	337	-	505	-	418
10040500	Salt Creek	37.6	169	294	377	-	476	-	382
10043350	Sheep Cr. Trib. No. 2	.34	3.2	6.1	8.3	11	-	-	5.4
10047500	Montpelier Creek	50.9	105	155	186	-	222	253	224
10058600	Bloomington Creek	24.4	140	187	215	245	-	-	222
10072800	Eightmile Creek	23.3	98	128	145	157	-	-	144
10090800	Battle Creek Trib.	4.5	43	81	104	121	-	-	98
10093000	Cub River	19.4	564	657	705	-	753	-	715
10099000	High Creek	16.2	204	231	245	250	-	-	250
10125000	Deep Creek	30.1	59	102	136	-	178	-	172
			Tributaries Between Great Salt Lake Desert and Bear River						
10172930	Right Hand Fk. Dove Cr.	12.2	4.1	13	25	40	-	-	32
10172940	Dove Creek	33.2	7.5	30	72	-	170	-	275
10172960	West Fork Tenmile Cr.	5.93	83	210	380	700	-	-	460

10172970	Rock Creek	44.0	167	437	741	1,100	-	-	1,390

			Discharge (cfs)						
		Drainage Area (square miles)	Recurrence Interval (years)						Maximum of Record
Station No.	Station Name		2	5	10	20	25	50	
Kootenai River Basin									
12304250	Whitetail Creek	2.61	27	42	53	64	-	-	49
12304300	Cyclone Creek	5.66	127	163	190	216	-	-	220
12304400	Fourth of July Creek	7.70	197	233	242	280	-	-	258
12310800	Trail Creek	16.1	175	284	390	520	-	-	341
12316800	Mission Creek	23.0	333	470	560	-	660	-	528
Pend 'Oreille River Basin									
12345800	Camas Creek	6.01	149	230	280	-	360	-	265
12347500	Blodgett Creek	26.4	637	753	814	-	880	-	836
12350200	Gash Creek	3.37	107	157	195	-	250	-	200
12350500	Kootenai Creek	28.9	830	1,100	1,330	-	1,400	-	1,300
12353800	Thompson Creek	12.2	60	101	132	165	-	-	190
12353850	East Fork Timber Cr.	2.72	35	52	65	78	-	-	66
12354100	N. Fk. Little Joe Cr.	14.7	190	210	220	225	-	-	212
12392100	Trapper Creek	1.12	34	47	56	65	-	-	52
12392800	Hornby Creek	2.2	37	44	48	56	-	-	48
12393600	Binarch Creek	10.7	64	104	132	160	-	-	117
12394300	Benton Creek	1.48	13	18	20	-	24	27	22.5

		Drainage	Discharge (cfs)						

			Discharge (cfs)						
			Recurrence Interval (years)						Maximum of Record
Station No.	Station Name	Area (square miles)	2	5	10	20	25	50	
Spokane River Basin									
12413100	Boulder Creek	3.13	97	130	150	173	-	-	144
12413200	Montgomery Creek	4.53	75	132	178	230	-	-	155
12415100	Cherry Creek	7.07	97	168	222	280	-	-	247
12415200	Plummer Creek Trib.	2.10	57	92	120	155	-	-	122
12416000	Hayden Creek	22.0	377	620	800	-	1,050	-	790
12423550	Hangman Creek Trib.	2.18	40	117	184	250	-	-	155
12423700	S. Fk. Rock Cr. Trib.	.59	27	34	39	43	-	-	41
12423900	Stevens Creek Trib.	2.02	22	44	68	-	117	-	125
12429600	Deer Creek	31.9	136	250	360	490	-	-	391
12430370	Bigelow Gulch	2.07	19	61	120	260	-	-	1,510
Tributaries to Snake River above Henrys Fork									
13027200	Bear Canyon	3.30	45	84	112	140	-		
13030000	Indian Creek	36.8	204	267	306	-	3		
Henrys Fork Basin									
13038900	Targhee Creek	20.8	235	300	335	370	-	-	340
13050700	Mail Cabin Creek	3.27	36	50	61	77	-	-	81
13050800	Moose Creek	21.4	285	360	410	450	-	-	390
13054400	Milk Creek	17.9	98	400	833	1,500	-	-	1,350

		Drainage	Discharge (cfs)

Station No.	Station Name	Area (square miles)	Discharge (cfs)						
			Recurrence Interval (years)						Maximum of Record
			2	5	10	20	25	50	
Tributaries to Snake River between Henrys Fork and Blackfoot River									
13057600	Homer Creek	26.4	220	410	550	700	-	-	448
13061100	Snake River Trib.	7.64	58	175	322	510	-	-	450
Blackfoot River Basin									
13062700	Angus Creek	13.9	188	272	334	400	-	-	375
13063500	Little Blackfoot River	38.8	140	209	275	-	318	-	292
Portneuf River Basin									
13073700	Robbers Roost Creek	5.70	14	21	26	29	-	-	24
13074000	Birch Creek	6.56	24	35	56	-	94	-	95
13075300	East Fork Mink Creek	14.7	28	45	54	63	-	-	49
13075600	N. Fk. Pocatello Cr.	14.0	23	42	58	76	-	-	57
13075700	S. Fk. Pocatello Cr.	4.3	2.3	5.0	8.0	13	-	-	9
Raft River Basin									
13077700	George Creek	7.84	67	102	124	150	-	-	146
13079000	Clear Creek	20.2	120	185	225	-	375	490	386
13079800	Heglar Canyon Trib.	7.72	185	360	580	900	-	-	1,930
Bruneau River Basin									
13152500	Columbet Creek	3.37	15	27	35	44	-	-	35
13170100	Sugar Creek Trib.	3.04	28	56	78	105	-	-	105

Station No.	Station Name	Drainage Area (square miles)	Discharge (cfs) Recurrence Interval (years) 2	5	10	20	25	50	Maximum of Record
Tributaries to Snake River between Bruneau River and Boise River									
13172200	Fossil Creek	19.7	22	135	175	240	-	-	195
13172668	ARS, W-13	.16	3.6	6.6	8.8	11	-	-	5.9
13172735	ARS, W-2	14.0	87	279	524	900	-	-	1,007
13172800	Little Squaw Cr. Trib.	1.81	12	44	75	115	-	-	93
Boise River Basin									
13184200	Roaring River	23.3	370	500	580	660	-	-	575
13184800	Beaver Creek	9.3	103	149	181	218	-	-	195
13185500	Cottonwood Creek	20.9	74	190	310	475	-	-	166
13196500	Bannock Creek	5.75	12	23	32	-	45	-	46
13200500	Robie Creek	15.8	59	106	160	-	255	-	274
13207000	Spring Valley Creek	20.9	50	129	206	-	336	-	244
13210300	Bryans Run	7.94	68	180	290	430	-	-	420

Station No.	Station Name	Drainage Area (square miles)	Discharge (cfs) Recurrence Interval (years) 2	5	10	20	25	50	Maximum of Record
Payette River Basin									
13234300	Fivemile Creek	7.8	158	214	247	280	-	-	290
13235100	Rock Creek	14.6	144	275	390	530	-	-	400

Station No.	Station Name	Drainage Area (square miles)	Discharge (cfs) Recurrence Interval (years) 2	5	10	20	25	50	Maximum of Record
13237300	Danskin Creek	10.1	36	60	76	94	-	-	71
13237600	Cabin Creek	.42	3.2	7.8	12	17	-	-	18
1323700	Control Creek	.59	3.8	11	18	27	-	-	6.6
13238300	Deep Creek	4.38	337	430	499	620	-	-	540
13240000	Lake Fork Payette R.	48.9	1,380	1,750	1,980	-	2,260	2,460	2,600
13245400	Tripod Creek	8.63	80	118	144	175	-	-	183
13248900	Cottonwood Creek	6.53	80	142	220	300	-	-	303
13250600	Big Willow Creek	47.4	890	1,600	2,140	2,700	-	-	2,100
13250650	Fourmile Creek	6.5	120	320	510	760	-	-	500
13250700	Langley Gulch	3.88	0	3.3	32	62	-	-	39
Weiser River Basin									
13251300	West Branch Weiser R.	3.96	34	53	76	103	-	-	84
13251500	Weiser River	36.5	460	660	790	-	1,020	1,200	1,320
13252500	East Fk. Weiser River	2.0	53	70	80	91	-	-	77
13257500	Johnson Creek	4.81	132	179	211	248	-	-	222
13267100	Deer Creek	4.6	67	112	140	170	-	-	156
Tributaries to Snake River between Weiser River and Salmon River									
13289600	East Brownlee Creek	7.97	78	190	290	420	-	-	325
Salmon River Basin									
13292400	Beaver Creek	15.0	138	176	200	230	-	-	225

13293000	Alturas Lake Creek	35.7	475	610	680	-	785	-	633
13297100	Peach Creek	7.62	26	62	95	136	-	-	105
13298300	Malm Gulch	9.38	85	300	471	600	-	-	440
13301700	Morse Creek	18.0	132	200	245	290	-	-	230
13301800	Morse Creek	19.9	18	70	105	246	-	-	90
13302200	Twelvemile Creek	22.0	41	61	75	89	-	-	70
13305700	Dahlonega Creek	32.0	95	162	216	273	-	-	235
13305800	Hughes Creek	15.7	146	193	218	240	-	-	220
13311000	E. Fk. S. Fk. Salmon R.	19.5	177	252	298	-	358	-	369
13311500	E. Fk. S. Fk. Salmon R.	42.5	340	510	620	-	780	-	783
13313800	Tailholt Creek	2.46	7.7	13	20	-	33	-	27
13315500	Mud Creek	15.8	200	290	350	-	435	510	395
13316000	Boulder Creek	5.84	160	220	265	307	-	-	244
13316800	N. Fk. Skookumchuck Cr.	15.3	130	240	360	-	580	-	471
13317200	Johns Creek	6.67	96	240	380	580	-	-	400

			Discharge (cfs)						
		Drainage Area (square miles)	Recurrence Interval (years)						Maximum of Record
Station No.	Station Name		2	5	10	20	25	50	
Tributaries to Snake River between Salmon River and Clearwater River									
13335200	Critchfield Draw	1.8	19	245	500	-	1,300	-	705
Clearwater River Basin									
13336600	Swiftwater Creek	6.19	83	114	133	145	-	-	150
13336650	E. Fk. Papoose Creek	4.51	77	114	135	147	-	-	125

13336850	Weir Creek	12.2	270	440	550	660	-	-	470
13337200	Red Horse Creek	9.13	92	141	185	220	-	-	200
13337700	Peasley Creek	14.2	79	120	158	220	-	-	240
13338200	Sally Ann Creek	13.9	191	251	284	320	-	-	305
13339700	Canal Gulch Creek	5.9	112	167	210	270	-	-	291
13339900	Deer Creek	6.8	79	215	350	550	-	-	485
13341100	Cold Springs Creek	8.25	59	140	215	310	-	-	200
13341300	Bloom Creek	3.15	51	94	133	175	-	-	151
13341400	E. Fk. Potlatch River	41.6	610	936	1,200	1,580	-	-	1,740
Palouse River Basin									
13344700	Deep Creek Trib.	2.90	54	82	104	130	-	-	157
13344800	Deep Creek	36.6	799	1,220	1,480	1,730	-	-	1,700
13346300	Crumarine Creek	2.41	13	19	24	28	-	-	24
13348400	Missouri Flat Cr. Trib.	.88	30	90	190	-	430	-	234
13348500	Missouri Flat Creek	27.1	315	520	940	-	1,600	-	1,500

Basin Characteristics

Descriptions and methods of determination of the five basin characteristics used in the regression equations are given below.

1. Drainage Area (A)

Drainage area is in square miles and is determined by outlining on the best available topographic map the surface water divide upstream from the point of interest on the stream and determining the area from the map using a planimeter. U.S. Geological Survey 7-1/2 or 15-minute quadrangle maps are recommended when available.

2. Forest Cover (F)

Forest cover is expressed as the percentage plus 1 percent of the drainage area covered by forests and is determined from a U.S. Geological Survey 1:250,000 scale map. A recommended procedure is to lay a grid over the basin outline, count the number of grid intersections lying within the forested (green) areas and the number of grid intersections within unforested areas and, from this, calculate the percentage of the basin that is forested.

3. Areas of Lakes and Ponds (La)

Areas of lakes and ponds are expressed as the percentage plus 1 percent of the drainage area covered by water (lakes, ponds, or swamps) and is determined by the grid method. See forest cover (F) above. U.S. Geological Survey 7-1/2 or 15-minute quadrangle maps are recommended when available.

4. Latitude (N)

Latitude is the latitude of the centroid of the basin in decimal degrees minus 40 degrees. It is determined from inspection of the basin as outlined on a U.S. Geological Survey 1:250,000 scale map.

5. Longitude (W)

Longitude is the longitude of the centroid of the basin in decimal degrees minus 110 degrees. It is determined from inspection of the basin as outlined on a U.S. Geological Survey 1:250,000 scale map.

Relative Magnitude of Floods

Comparison of estimates of floods at ungaged sites with the maximum floods known is useful in evaluating the relative magnitude and to ascertain the credibility of the estimates. The maximum known flood is often used as the design flood. Relative magnitude of floods is desirable for use in both planning and design.

The maximum discharges of record for streams in Idaho that are significant for comparative purposes are plotted against drainage areas in Figure B-10. The plot includes significant maximum discharges at miscellaneous sites as well as at short-term gaging stations. The plot also shows the wide range of peak discharges that have been recorded. Peak discharges, as computed by the outlined method, should be checked for credibility by plotting on the graph and comparing with the flows experienced at nearby stations. Only the stations with maximums of record greater than 100 cfs/mi^2 have been identified by station number. A specific site in Tables B-2 and B-3 can be identified on the graph using the drainage area and maximum discharge from the figures.

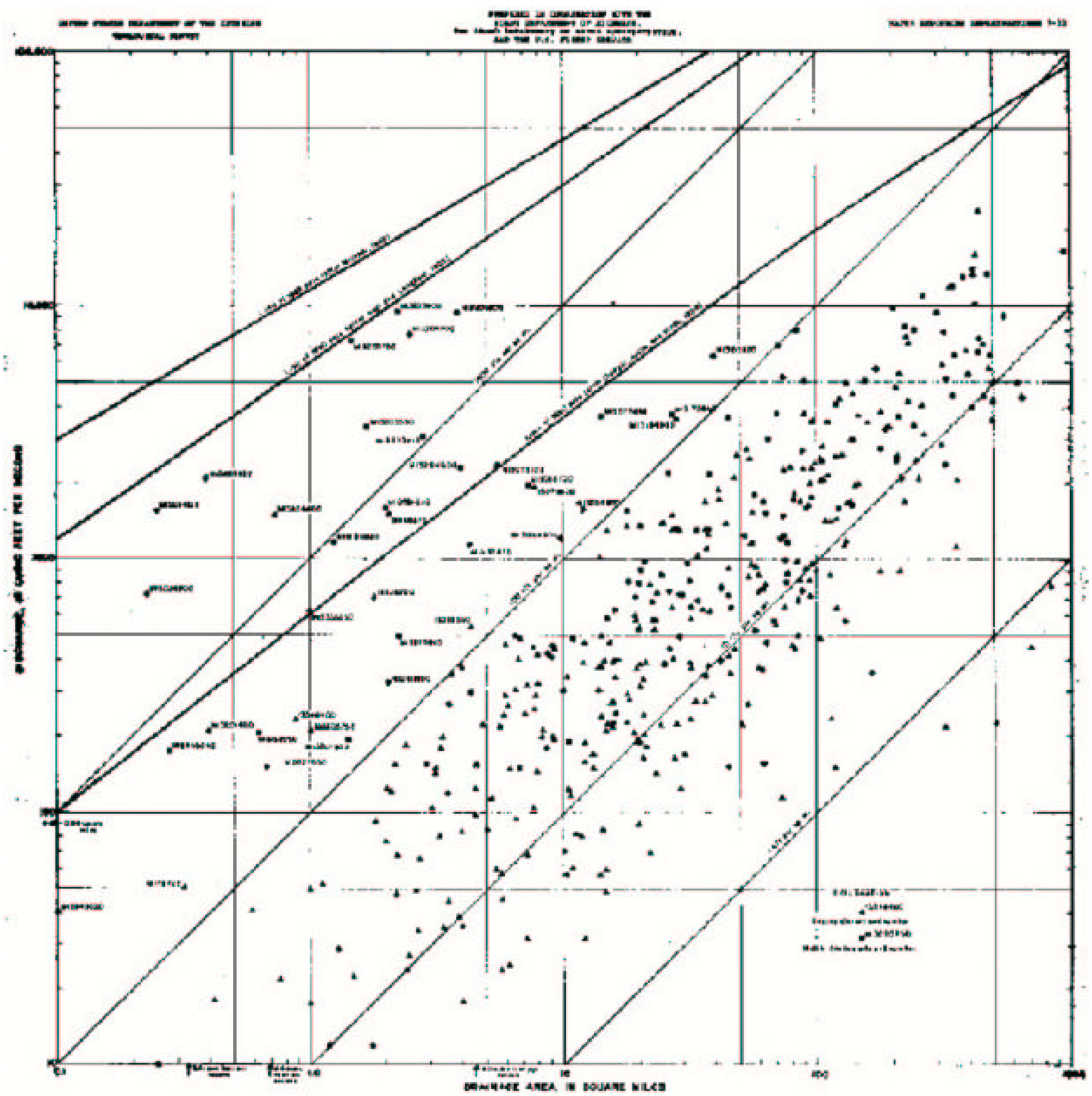
For comparative purposes, three curves are shown in Figure B-10: The Matthai curve (Matthai, 1969, p. B6) is an average through the highest known floods recorded in the United States up to 1965; the Hoyt and Langbein curve (Matthai, 1969, p. B6) is an average through the maximum floods recorded prior to 1950; and the Creager, Justin, and Hinds curve (Matthai, 1969, p. B6) is an average through the maximum known flood data available in 1890. Concerning the increase between the 1890 and 1950 curves, Hoyt and Langbein (Matthai, 1969, p. B6) stated: "This is no evidence that flood conditions are changing. The upward shift of the curves . . . is due entirely to an increased number of gaging stations and increased period of record."

As more records become available, the upper limits of the maximum known flood plot will move upward as additional rare floods are measured. Nevertheless, Figure B-10 is indicative of what can be expected in the future.

Generalizations regarding magnitude and frequency of floods in Idaho can be made from Figure B-10. Floods greater than about 300 cfsm have rarely been observed on basins greater than 4 square miles. Most floods having rates greater than 300 cfsm occur in unforested basins, a few of which have been denuded by range fires. This large a flow has been recorded at only one site on a forested basin, Canyon Creek tributary near Lowman (M13234215), and there the forest cover was light.

All floods greater than 300 cfsm were from intense thunderstorms and were unassociated with snowmelt. All basins with floods greater than 100 cfsm have drainage areas less than 40 square miles, and only five of these floods were not caused by intense thunderstorms. Conversely, a flood greater than 100 cfsm has not yet been recorded in Idaho on a basin larger than about 400 square miles. Evidently, floods that plot to the left of any of the three curves in Figure B-10 have long recurrence intervals and are rare.

Figure B-10



MAXIMUM DISCHARGES IN RELATION TO DRAINAGE AREA

Table B-3

MAXIMUM DISCHARGES AT SELECTED SITES

Station No.	Stream Name	Drainage Area (sq. mi.)	Date	Discharge (cfs)
	Bear River Basin			
10041000	Thomas Fork near Wyoming-Idaho State Line	113	05-18-50	869
10047000	Montpelier Creek near Montpelier	28.2	04-24-43	224
10071500	Skinner Creek near Nounan	5.41	06-08-44	60
10087500	Mink Creek below Dry Fork	19.3	05-29-48	600
M10091030	Battle Creek Tributary No. 2	a2	08-21-61	1,600
10119000	Little Malad River	120	02-10-62	1,450
M10120030	Little Danish Canyon	1.25	08-25-61	1,170
10091200	Deep Creek near Clifton	119	03-31-69	152
10120500	Little Malad River	223	02-11-62	1,720
M10122550	Devil Creek	15	02-01-63	585
M10172966	Deep Creek	a72	02-11-62	1,220
	Tributaries to Great Basin between Great Salt Lake Desert and Bear River			
M10172973	Rock Creek	93	02-10-62	1,630
M10172974	Wood Canyon	a1.3	02-10-62	29
	Kootenai River Basin			
12305500	Boulder Creek	53	05-30-69	2,720
12309000	Cow Creek near Bonners Ferry	14.7	06-09-33	60
12311000	Deep Creek at Moravia	133	05-18-54	1,670
12311500	Snow Creek near Moravia	19.5	06-14-33	572
12312000	Caribou Creek near Moravia	14.0	06-15-33	376
12313000	Myrtle Creek near Bonners Ferry	a37	06-05-33	1,260
12313500	Ball Creek near Bonners Ferry	a27	06-15-33	644
12315200	Rock Creek near Copeland	14.3	04-26-23	86
12315400	Trout Creek near Copeland	a20	06-16-33	533
12317000	Mission Creek at Copeland	a31	05-22-32	370
12317500	Brush Creek near Copeland	a7.2	04-26-33	68
12319500	Parker Creek near Copeland	16.5	06-15-33	400
12320500	Long Canyon Creek near Porthill	a29	05-27-48	1,300
12321000	Smith Creek near Porthill	a70	06-23-55	3,810
12321500	Boundary Creek near Porthill	a97	06-23-55	3,280

Pend 'Oreille River Basin				
M12392120	East Fork Creek	20.4	06-08-64	903
M12392150	Lightning Creek	90	05-27-48b	5,100
12392300	Pack River	124	05-30-69	4,370
12392400	Rapid Lightning Creek	45	04-20-65	718
M12392950	Indian Creek	20	05-27-48b	800
Spokane River Basin				
M12411800	East Fork Eagle Creek	9.13	06-08-64	457
M12411900	Cottonwood Creek	2.05	06-08-64	328
M12413120	Canyon Creek	18.1	06-08-64	817
12413140	Placer Creek at Wallace	14.9	12-23-64	a1,300
12413700	Latour Creek near Cataldo	24.8	02-19-68	1,400
M12413450	Pine Creek	74.0	12-23-64	5,290
Station No.	Stream Name	Drainage Area (sq. mi.)	Date	Discharge (cfs)
Spokane River Basin (continued)				
M12413470	South Fork Coeur d'Alene River	310	02-21-61	9,440
M12413900	St. Joe River	472	05-29-48	13,400
M12413950	North Fork St. Joe River	111	05-28-48	3,500
12415000	St. Maries River	437	12-22-33	23,800
Salt River Basin				
13025500	Crow Creek near Fairview, WY	114	04-19-46	236
13026000	Stump Creek near Auburn, WY	103	05-18-48	490
Tributaries to Snake River between Salt River and Henrys Fork				
M13034900	Snake River Tributary No. 7	.23	06-01-63	729
13035500	Pine Creek near Swan Valley	63.2	05-16-36	799
M13037600	Birch Creek	21	02-11-62	980
M13038410	Lyons Creek	a18	02-11-62b	1,560
Henrys Fork Basin				
13041500	Sheridan Creek near Island Park	82.1	05-31-38	447
13047800	N. Fk. Squirrel Cr. near Squirrel	2.40	05-16-64	184
13051000	Trail Creek near Victor	47.6	06-07-52	445
13051500	Teton Creek near Driggs	33.8	06-06-52	1,030
13052500	Horseshoe Creek near Driggs	11.7	05-03-52	81
13053000	Packsaddle Creek near Tetonia	5.7	05-19-49	58
M13054600	Canyon Creek	a76	02-11-62b	814
M13-55320	Moody Creek	a88	02-11-62b	2,700

Station No.	Stream Name	Drainage Area (sq. mi.)	Date	Discharge (cfs)
Willow Creek Basin				
13058000	Willow Creek	622	02-11-62	5,080
Tributaries to Snake River between Shelley and Blackfoot				
M13059100	Snake River Tributary No. 5	5.2	02-11-62	114
M13059200	Snake River Tributary No. 4	3.55	02-11-62	270
M13059300	Snake River Tributary No. 3a	3.5	02-11-62	120
M13059400	Snake River Tributary No. 3	16	02-11-62	632
M13062600	Snake River Tributary No. 6	63.5	02-11-62	1,540
Blackfoot River Basin				
M13066600	Sand Creek Tributary	a9.8	02-11-62	1,210
M13066700	Black Canyon	7.29	08-09-63	1,940
M13066800	Henrys Creek	a29	02-11-62	716
M13066900	Cedar Creek	10.5	02-11-62	194
Portneuf River Basin				
13071500	Topons Creek near Chesterfield	45.7	05-21-12	355
M13072100	Portneuf River Tributary	a130	02-01-63	574
M13072300	Portneuf River	332	02-11-62b	2,380
M13072750	Fish Creek	20.1	02-01-63	1,360
M13072900	Dempsey Creek	42	02-01-63	400
M13073100	Jenkins Canyon	5.50	08-01-60	2,350
M13073710	Green Canyon Tributary	2.82	08-12-61	3,060
M13073720	Portneuf River	650	02-13-62	4,380
M13073750	Marsh Creek	a68	02-12-62	573
13074000	Birch Creek near Downey	6.56	07-15-38	95
M13075100	Rapid Creek	57.2	02-01-63	526
M13075400	Gibson Jack Creek	10.3	02-12-62	57
Bannock Creek Basin				
13076000	Bannock Creek	227	12-24-64	7,790
M13076100	Rattlesnake Creek	a77	02-11-62b	1,170
M13076200	Bannock Creek	413	02-11-62	4,010
Rock Creek Basin				
M13077100	Trail Creek	a11	09-09-61	487
M13077200	Rock Creek	96	02-11-62	1,770
M13077400	Rock Creek	156	02-01-63	5,100
M13077550	Rock Creek	216	02-11-62	2,120

Station No.	Stream Name	Drainage Area (sq. mi.)	Date	Discharge (cfs)
M13077630	Spring Canyon Tributary	6.77	08-18-61	152
M13077640	Rocky Hollow Tributary	2.26	05-30-63	498
M13077650	Rock Creek	320	12-23-64	7,950
Tributaries to Snake River between Rock Creek and Raft River				
M13077652	Dairy Canyon	26.2	01-17-71	750
M13077655	Fall Creek	14.2	07-10-70	3,700
Raft River Basin				
13079070	Meadow Creek near Sublett	37.7	05-09-71	626
13079100	Cassia Creek above Stinson Creek	7.2	06-24-69	32
13079200	Cassia Creek near Elba	a84	12-23-64	982
M13079750	Heglar Canyon	a45	02-11-62	153
M13079820	Heglar Canyon	62.0	01-17-71	471
M13079890	Calder Creek	23.6	01-17-71	735
Tributaries to Snake River between Raft River and Big Wood River				
13082300	Marsh Creek near Albion	a86	01-17-71	828
13083000	Trapper Creek near Oakley	53.7	08-17-41	270
M13084800c	"D" Drain Tributary	5.0	12-23-64	86
M13084900c	"F" Drain	64.7	12-23-64	2,990
13088500	Big Cottonwood Creek near Oakley	a29	05-30-12	125
13092000	Rock Creek near Rock Creek	a80	05-19-70	461
13108500	Camas Creek at Eighteenmile Shearing Corral	a210	05-08-69	2,590
13113000	Beaver Creek at Spencer	a120	04-24-69	642
13114000	Beaver Creek at Camas	510	04-21-62	229
13116000	Medicine Lodge Creek	165	04-15-62	361
13117000	Birch Creek near Reno	320	04-01-62	220
13117300	Sawmill Creek near Goldburg	74.3	06-12-65	651
13119000	Little Lost River near Howe	703	08-11-36	450
13120000	N. Fk. Big Lost R. at Wild Horse	114	06-12-65	1,420
13129800	Alder Creek below South Fork	27.6	05-24-67	165
13130900	Antelope Creek above Willow Creek	93.4	05-24-67	829
M13132540	Big Lost Tributary	a20	02-11-62	190
M13132555	Big Lost River Tributary No. 2	a8.7	02-11-62	424
Big Wood River Basin				
13135500	Big Wood River near Ketchum	137	05-24-67	1,690
13136500	Warm Springs Creek at Guyer Hot Springs	a96	05-21-58	961

M13142850	Big Wood River Tributary	15.8	02-12-62	226
M13145800	Thorn Creek	a46	02-11-62	647
M13145900	Preacher Creek	a26	12-23-64	2,210
M13147100	Dry Creek	a84	12-22-64d	8,050
13150500	Silver Creek	a88	02-04-63	757

Station No.	Stream Name	Drainage Area (sq. mi.)	Date	Discharge (cfs)
Clover Creek Basin				
M13153800	Clover Creek	71.2	12-23-64	7,000
M13153900	Calf Creek	39.4	12-23-64	6,400
13154000	Clover Creek near Bliss	140	02-13-70	4,500
M13154400	Clover Creek	265	12-23-64	10,100
Tributaries to Snake River between Clover Creek and Bruneau River				
13155000	King Hill Creek near King Hill	78.9	02-01-63	2,320
M13155100	Rosevear Gulch	55.9	08-31-63	1,160
13155400	Little Canyon Cr. at Berry Ranch	26.9	12-23-64	1,330
13156500	Bennett Creek near Bennett	21.3	04-02-43	204
13157000	Bennett Creek near Hammett	68.6	02-16-13	550
M13161050	Squaw Creek	61.5	09-16-61	368
Bruneau River Basin				
13163200	Sheep Creek	a180	06-05-63	2,760
M13168380	Hot Creek	42.2	08/13/68	772
M13169250	Bruneau River Tributary	.63	08-13-68	208
13169500	Big Jacks Creek	253	02-21-43	2,100
13170000	Little Jacks Creek	100	01-21-43	908
M13170200	Sugar Creek	33.6	08-13-68	1,300
Tributaries to Snake River between Bruneau River and Boise River				
M13172100	Browns Creek	a31	08-13-68	967
M13172300	Sinker Creek	a74	12-23-64	1,500
M13172600	Rabbit Creek	a45	06-19-62	3,640
M13172620	Rabbit Creek Tributary	4.3	06-19-62	1,140
M13172640	West Rabbit Creek	27.0	06-20-62	3,740
M13172700	Nancy Gulch	a4	06-19-62	375
13172720	Macks Creek	12.3	01-28-65	390
13172725	Reynolds Creek Tributary	.32	06-19-69	50.7
13172740	Reynolds Creek	90.2	12-23-64	3,800
13173500	Sucker Creek	413	02-01-63	13,300

13178000	Jordan Creek	440	12-24-64	7,530

Station No.	Stream Name	Drainage Area (sq. mi.)	Date	Discharge (cfs)
Boise River Basin				
M13184950	Sheep Creek	28.2	12-23-64	3,590
13187000	Fall Creek	55.3	04-27-52	1,150
M13192400	Rattlesnake Creek	37.8	12-23-64	1,320
M13192900	Willow Creek	57.0	12-23-64	1,820
13198000	Elk Creek	13.1	08-17-41	172
M13201400	Sheep Creek	0.40	08-20-59	210
M13203520	Highland Valley Gulch	.39	08-20-59	2,100
M13203530	Highland Valley Gulch	1.69	08-20-59	3,370
M13203600	Maynard Gulch	2.25	08-20-59	9,540
M13203750	Squaw Creek	1.47	08-20-59	7,320
M13203800	Warm Springs Creek	3.84	08-20-59	9,390
M13204600	Orchard Gulch	.73	08-20-59	1,500
M13204700	Picket Pin Creek	2.50	08-20-59	7,720
M13204800	Cottonwood Gulch	12.0	08-20-59	1,580
M13204900	Curlew Gulch	3.95	08-20-59	2,300
M13205650	Ussery Street Gulch	.06	06-21-67	90
M13205700	Stuart Gulch	9.04	01-29-65	412
M13205750	Polecat Gulch	1.01	06-21-67	210
M13205800	Boise River Tributary	.25	06-21-67	9.8
M13205850	Pierce Gulch	1.18	06-21-67	12
M13206100	Seaman Gulch	1.76	06-21-67	12
M13207650	Goose Creek	1.42	05-20-68	195
Payette River Basin				
M13234215	Canyon Creek Tributary	a.25	07-09-68	1,550
13234500	Clear Creek	59.6	05-31-43	754
13235500	Deadwood River	10.4	06-15-52	354
13236500	Deadwood River	112	05-26-28	2,150
M13237820	Lightning Creek	24.4	12-23-64	864
M13237840	Scriver Creek	27.3	12-22-55	406
M13237900	Anderson Creek	34.0	12-22-55	690
13247000	Porter Creek	21.2	08-11-41	181
M13248800	Shafer Creek	74.6	12-22-55	1,240

M13249050	Cottonwood Creek	29.6	12-22-55	722

Station No.	Stream Name	Drainage Area (sq. mi.)	Date	Discharge (cfs)
Payette River Basin (continued)				
M13249100	Little Squaw Creek	75.3	12-22-55	1,000
M13249200	Squaw Creek	345	12-22-64	12,000
M13250680	Big Willow Creek	138	01-15-56	1,640
Weiser River Basin				
13253000	East Fork Weiser River	31.6	12-22-55	821
13253500	Weiser River at Starkey	106	03-27-40	2,450
M13260100	West Fork Pine Creek	a29	12-22-55	499
13255500	Hornet Creek near Council	107	12-22-55	2,090
13257000	Middle Fork Weiser River	86.5	12-22-55	1,710
13259500	Rush Creek	32.0	03-16-38	582
13260000	Pine Creek	a54	02-25-58	850
13261000	Little Weiser River	81.9	02-24-25	a1,840
M13261600	Little Weiser River	206	12-22-55	4,800
M13261650	Weiser River	952	12-22-55	16,600
M13263700	Crane Creek	a120	12-22-55	4,120
M13263750	Hog Creek	a25	12-22-55	338
M13263800	Mill Creek	a10	12-22-55	305
M13263950	South Fork Crane Creek	a52	01-17-70	1,240
13267000	Mann Creek	a56	03-27-40	1,540
13268500	Monroe Creek	a32	02-27-40	a650
Tributaries to Snake River between Weiser River and Salmon River				
M13269230	Hog Creek	22.5	01-17-70	681
M13289650	Brownlee Creek	a62	12-22-55	159
M13289900	Wildhorse Creek	a120	12-22-55	2,550
M13289950	Wildhorse Creek	a140	12-22-55	2,990
13290190	Pine Creek	a230	02-21-68	2,110
Salmon River Basin				
13292500	Salmon River	94.7	05-29-52	721
13295000	Valley Creek	147	05-24-56	2,000
13296000	Yankee Fork Salmon River	195	06-12-21	3,360
M13297200	Slate Creek	a28	08-09-63	1,580
13297300	Holman Creek	6.10	06-13-65	a25
13297450	Little Boulder Creek	18.4	06-25-71	279

Station No.	Stream Name	Drainage Area (sq. mi.)	Date	Discharge (cfs)
13299200	Challis Creek	91.2	06-12-65	918
Salmon River Basin				
13302000	Pahsimeroi River	845	06-08-57	796
13306000	North Fork Salmon River	214	06-13-33	901
13308500	Middle Fork Salmon River	138	05-24-561	2,980
13309000	Bear Valley Creek	180	05-27-56	3,860
13310000	Big Creek	470	06-03-48	5,800
13310500	South Fork Salmon River	92	05-27-56	1,620
M13310700	South Fork Salmon River	324	05-28-48	5,200
13312000	East Fork South Fork Salmon River	104	06-14-33	2,050
13312500	Johnson Creek	54.7	05-27-48	1,510
13313000	Johnson Creek	213	05-27-56	5,440
M13313200	East Fork South Fork Salmon River	424	05-28-48	10,400
13313500	Secesh River	104	06-03-48	2,500
13314500	Warren Creek	37	06-03-48	1,100
M13315800	Little Salmon River	189	06-01-48	3,300
M13316200	Little Salmon River	345	12-22-55	4,480
M13316300	Indian Creek	2.66	05-20-70	34
M13316400	Rapid River	122	05-29-48	1,600
M13316450	Little Salmon River	550	06-01-48	9,200
M13316600	Slate Creek	127	06-01-48	2,600
M13317050	White Bird Creek	a96	05-22-48	3,500
13317500	Deer Creek	19.1		209
Tributaries to Snake River between Salmon River and Clearwater River				
M13335250	Snake River Tributary No. 8	1.0	06-08-64e	622
Clearwater River Basin				
M13335420	Selway River	211	05-28-48	3,700
M13336620	White Sand Creek	244	05-29-48	8,100
M13336630	Crooked Fork	172	05-29-48	5,700
13336800	Warm Springs Creek	74.7	06-13-59	2,260
13336900	Fish Creek	89.2	05-20-64	2,280
M13337550	South Fork Clearwater River	434	05-29-48	6,600
M13338300	Cottonwood Creek	81.7	01-29-65	1,740
M13338950	Lawyer Creek	208	01-29-65	2,460
13339500	Lolo Creek	243	06-08-64	3,430

Station No.	Stream Name	Drainage Area (sq. mi.)	Date	Discharge (cfs)
M13340200	North Fork Clearwater River	201	05-28-48b	9,900
Clearwater River Basin (continued)				
M13340400	Kelly Creek	380	05-28-48b	13,000
M13340800	Little North Fork Clearwater River	414	05-29-48	14,000
M13341140	Big Canyon Creek	225	01-29-65	8,360
13341500	Potlatch River	424	01-29-65	16,000
M13341800	Lapwai Creek	37.9	01-29-65	2,190
13342000	Mission Creek	a16	01-29-65	a400
M13342400	Lapwai Creek	235	01-29-65	4,380
M13343020	Lindsay Creek Tributary No. 1	.10	07-16-64	40.6
M13343040	Lindsay Creek Tributary No. 2	.28	07-16-64	176
M13343060	Lindsay Creek Tributary No. 3	4.25	07-16-64	300
13345000	Palouse River	317	01-00-48	12,000

a Approximately.
b Date may have been day following that indicated.
c Flood discharge may be affected by canals, drains, or other works of man.
d Date may have been 12-24-64.
e Date may have been 07-16-64.

Example One – Application of the Design Method

Determine the 10-, 25- and 50-year floods for Bloom Creek at the mouth near Bovill.

Step 1: The mouth of Bloom Creek is in Section 3, Township 41 North, Range 1 East, and the basin is entirely on the U.S. Geological Survey Bovill 15-minute quadrangle map. A continuous-record gage (Station 13341300) was operated at the site (Figure B-9, sheet 1). Records are available from 1959 to 1971. Figures of peak discharge through the 20-year flood computed by the log-Pearson Type III method (Water Resources Council, 1967) are listed in Table B-2. A check of Figure B-9 indicates the design method applies. The site and basin are in Region 1.

Step 2: Table D-1 indicates drainage area (A) is the only basin characteristic that needs to be determined for the Region 1 regression equation. Forest cover (F) also should be determined for evaluation purposes.

Step 3: The drainage area for the Bloom Creek, as previously determined by planimetering from the Bovill quadrangle, is 3.15 square miles. Forest cover (F) is determined to be 101.

Step 4: Using either the nomograph or the regression equation and the ratios for Region 1, the 10-year flood is found to be about 135 cfs, the 25-year flood is about 175 cfs, and the 50-year flood is about 200 cfs. From Table D-2, Q_{10} by the modified log-Pearson Type III method for Bloom Creek is 133 cfs, which closely checks the figure from the nomograph and the equations.

Step 5: No limitation appears to apply to this stream. None of the basin is urbanized. Forest cover index is 101, well above the recommended minimum requirement of 30 for application of the Q_{25}/Q_{10} and Q_{50}/Q_{10} ratios. No regulation or diversion that affects the peaks is known. Base flow (the flow after direct runoff from rain or snowmelt has stopped) as observed in late summer is low, indicating no significant effect from groundwater runoff. Alluvium, lava flows, or intense thunderstorms do not appear to affect this area significantly. Also, there are no anomalous areas nearby. Discharge plotted against the drainage area in Figure B-10 appears reasonable compared with plots for nearby streams. For example, a crude check of the data is provided by plotting the 175 cfs (Q_{25} for Bloom Creek) against its drainage area (3.15 square miles) and comparing it with a plot of Q_{25} versus the drainage area for East Fork Potlatch River (No. 13341400) and other basins nearby. They appear to plot near the same position with respect to the 100 cfsm line.

Example Two – Application of the Design Method

Determine the 25-year flood for a site on Targhee Creek below the confluence of the East Fork with Targhee Creek.

Step 1: The site is located in the NE 1/4 NE 1/4 of Section 1, Township 16 North, Range 43 East, which is on the U.S. Geological Survey Targhee Pass 7-1/2 minute quadrangle map. The basin lies on Targhee Pass and Targhee Peak 7-1/2 minute quadrangle maps and the Hebgen Dam 15 minute quadrangle map. A crest-stage gage (Station 13038900) was operated from 1963 to 1971 at a site 5 miles downstream (Figure B-9, sheet 3). From Figure B-9, the site and basin are in Region 6.

Step 2: Table D-1 indicates the basin characteristics to be determined are area (A), area of lakes and ponds (La), and latitude of the basin centroid (N). Forest cover should be determined for evaluation purposes.

Step 3:

- A = 10.5
- La = 0.4 + 1.0 = 1.4
- N = 4.7
- F = 44 + 1 = 45

Step 4: Using the appropriate regression equation, a 25-year flood of 136 cfs is indicated. The details of the computation using the regression equation are as follows:

- $Q_{10} = 188\ A^{0.873}\ La^{0.733}\ N^{-1.82}$

$= 188 \times 10.5^{0.873} \times 1.4^{0.773} \times 4.7^{-1.82}$

$= 188 \times 7.79 \times 1.30 \times 0.060 = 113$ cfs

- $Q_{25} = 113 \times 1.2 = 136$ cfs

The peak discharge should be rounded to two significant figures, but were used as computed for ease of checking.

Urbanization or regulation does not affect the peaks. Small diversions for irrigation probably do not affect the peaks because peaks normally occur before the irrigation season. Base flows as observed in late summer is low, indicating no significant effect from groundwater runoff. Alluvium and lava flows do not appear to alter the peak characteristics.

The relative magnitude of the Q_{25} from the nomograph can be compared with a Q_{25} for the crest-stage gage on Targhee Creek (Station 13038900). From Table D-3, Q_{10} for Targhee Creek is 335 cfs. Using the regional ratio for Q_{10}/Q_{25} of 1.2, Q_{25} equals 335 x 1.2 = 402 cfs. The ratio of the drainage areas at the subject site and the crest-stage gage site is 10.5/20.8, or 0.50. On the basis of the drainage area ratio and the record at the crest-stage gage, Q_{25} at the subject site would be 402 x 0.50 =201 cfs. This is 48 percent greater than the 136 cfs from the equation. In Region 6, Q_{50} is only 1.1 times Q_{25}, therefore, the design flood might be chosen on basis of maximum discharges at nearby sites rather than that for a selected recurrence interval. On Figure B-10, maximum discharges at nearby stations, including Stations 1311300, 13047800 and 13051500, plot above and below the Q_{25} of 136 cfs. Because the relation with the gaging station on Targhee Creek indicates a higher discharge and since maximum discharges at several nearby sites are considerably higher, a conservative discharge may be obtained by increasing the Q_{10} discharge by one standard error, or 41 percent (see Table B-1).

Design Discharge = 1.41 (113) 1.2 = 191 cfs

Example Three – Application of the Design Method

Determine the 50-year flood for Cottonwood Creek at the mouth near Horseshoe Bend.

Step 1: The site is in Section 3, Township 6 North, Range 2 East, which is on the Horseshoe Bend 7-1/2 minute quadrangle map. The basin lies on the Horseshoe Bend and Cartwright Canyon 7-1/2 minute quadrangle maps. A crest-stage gage (Station 13248900) was operated at this site from 1961 to 1971. From Figure B-9, sheet 2, the site is in Region 3.

Step 2: Table B-1 indicates the basin characteristics to be computed are area (A), forest cover (F), and latitude of the basin centroid (N).

Step 3:

- A = 6.53 square miles
- F = < 30

$$\text{Forest Factor} = \frac{(31-F)(30^{-0.216} - 31^{-0.216})}{2} + 31^{-0.216}$$

Forest Factor = 0.476

- N = 3.85

Step 4: The nomograph gives a Q_{50} flood of 440 cfs using the regression equation. The 10- and 50-year floods are as follows:

- $Q_{10} = 3.81A^{0.875}$ (Forest Factor) x $N^{2.02}$

= $3.81 \times 6.53^{0.875} (0.476)\ 3.85^{2.02}$

= 3.81 x 5.16 x 0.476 x 15.2 = 143 cfs

- Q_{50} = 143 x 1.5 = 214 cfs

Step 5: Urbanization or regulation does not affect the peaks. Field inspection indicates that some flow will bypass the site during extreme floods. Peaks generally occur during the winter and would not be affected by irrigation diversions.

The channel is dry for long periods, indicating that no large springs feed the stream. The generalized geologic map of Idaho (Ross, 1947) shows that above 40 percent of the basin is on granitic rock, which is relatively impermeable, and about 60 percent is on the weakly consolidated sedimentary rocks that are variable in permeability from one location to another. Course alluvium or fractured lava deposits are not extensive. Extreme floods from thunderstorms have been recorded within 20 miles to the southeast (Figure B-11, sheet 2). There is no significant forest cover on the basin, and forest cover (F) is 0 + 1 = 1. A Q_{10} of 220 cfs by the modified log-Pearson Type II method is reasonably well defined by 10 years of record. However, the Q_{50}/Q_{10} ratio is not well defined for this or other forested basins in any region of the state. Comparison with plots of discharge for nearby streams in Figure B-10 also indicates a wide divergence of peak flows for this area.

Because of uncertainties of the definition of discharges at long recurrence intervals, the designer should consider several alternatives. No intense thunderstorms have been recorded in the immediate area, although some have been experienced just over the ridge to the south [see Site M13207650 (Figure B-11, sheet 2, and Table B-3) and others on the Boise front, near Boise (Figure B-11, sheet 2)]. In addition to the thunderstorm floods nearby, maximums for Big Willow Creek near Emmett, Fourmile Creek near Emmett, Bryans Run near Boise, Spring Valley Creek near Eagle, and the magnitude and frequency data for the subject site should be considered in assessing the flood potential and risk at long recurrence intervals.

A reasonable design discharge for all but the extremely rare events could be determined by increasing the Q_{50} discharge by percentages equivalent to one standard error as follows: Q_{50} at the site was determined to be 450 cfs. Standard error for Region 3 is 51 percent. Increasing 450 by 51 percent gives a more conservative discharge of 680 cfs. If damage would be extreme from a structural failure, a discharge equivalent in percent to some larger multiple of the standard error may be added to the discharge from the nomograph.

PREPARED IN COOPERATION WITH THE
IDAHO DEPARTMENT OF HIGHWAYS,
THE IDAHO DEPARTMENT OF WATER ADMINISTRATION,
AND THE U.S. FOREST SERVICE

FIGURE 2.--MAP OF IDAHO SHOWING BASIN BOUNDARIES AND MAXIMUM KNOWN UNIT DISCHARGES AT MISCELLANEOUS SITES.

Base from U.S. Geological Survey
1:500,000

B.40.03 Undefined Areas Where Regression Relations Do Not Apply. Regional regression relations should apply to areas that are homogenous with respect to variables that affect the flow. Regression equations may not apply to basins in which the basin or flow characteristics are outside the range of those characteristics used to define the regional regression relations. Variations in topography, climate, geology, land use, and regulation or stream flow in Idaho often result in abrupt changes in flow and basin characteristics. Some of these variations are inadequately defined by available data. The following sections describe the poorly defined areas and discuss the reasons the regression relations are inapplicable.

Areas in which regional regression relations are not defined total about 20,000 square miles and are outlined in Figure B-9. In addition to these areas, smaller undelineated areas are scattered throughout Idaho.

In general, the undefined areas are mostly arid or semiarid. Stream flow in small streams is usually ephemeral (flowing only in direct response to precipitation or short-lived snowmelt) or intermittent (flowing only part of the time, such as during the snowmelt period or during wet periods in winter). Records are sparse and short in length. Therefore, flood flow magnitudes and frequencies have not been defined.

In addition to areas of poor definition, peak flows in many small basins are affected by urbanization, regulation, significant quantities of groundwater runoff, and large losses or gains associated with alluvial valleys and lava flows, intense thunderstorms, unusual climatic or physical basin characteristics, or a combination of these factors.

1. Unforested Areas

Most of the unforested areas of the state are in the arid or semiarid areas where precipitation is too low to support forestation. Nearly all of the area designated as undefined in Figure B-9 are unforested. Small streams are usually ephemeral or intermittent and the volume of runoff is low. Only a few records are available to define the magnitude and frequency of floods on these areas, and very few records are available to define the Q_{25}/Q_{10} and Q_{50}/Q_{10} ratios.

Because a small percentage of forest cover appears to be indicative of the ephemerality of streams in small basins, basins with less than 30 percent forest cover (F <30) are assumed not defined by methods used in this report.

Judgment and the maximum unit discharge of record for nearby streams, as shown in Figure B-11, are the best bases that can be recommended for the determination of discharge in unforested basins.

2. Urbanized Areas

Urbanization drastically changes basin features, which increase in paved areas, and the addition of sewerage are the most obvious. Both decrease the concentration time of the basin, which increases the intensity of floods and the frequency of flooding. Climates have been observed to change in or near large cities. Precipitation, temperature, humidity, cloudiness, and wind speed may be altered to some degree in urban areas. Also, urbanization is often accompanied by infringements on the natural flood channel and the flood plain, thus increasing flood heights. On the other hand, storm sewers may bypass surface flows past some sites, thus reducing peaks in natural channels.

Studies in other parts of the country indicate that for a basin of 1 square mile that is completely storm sewered and whose surface is completely (or 100 percent) impervious, the mean annual flood (approximately the 2-year flood) is about eight times larger than for the natural basin. The mean annual flood from a basin of 1 square mile that is completely storm sewered but 0 percent impervious is about 1.7 times as large as the natural basin. The mean annual flood for a basin that is completely impervious but not sewered is about 2.5 times as large as for the natural basin (Leopold, 1968). Very little information of this type is available regarding discharges from urbanized areas in Idaho.

3. Regulated Streams

South of about 45^{o} 30' north latitude, most agriculture (except grazing and dry farming) requires irrigation. Roughly 5,500 sq. mi. (or nearly 7 percent of the total area of the state) is irrigated, of which nearly 80 percent is irrigated from surface streams. Irrigated areas in the state are shown in Figure B-9.

Streams that reach the irrigated lands may be affected by one or a combination of the following: regulation, diversion, consumptive use, and return flow from irrigation. The impact on natural flood peaks is significant. Peak flows in many natural channels are drastically reduced and regional regression equations usually do not apply directly.

Determination of realistic design discharges requires that manmade effects be considered. Sources of data for estimating peak flows in these streams include records of performance of existing structures such as canals, bridges, ditches, drains, etc.; watermaster records of water use; streamflow records; verbal reports from local residents; and estimates of natural peak flows using basin characteristics. Contributing areas upstream during flood periods are sometimes difficult to define because of storage in reservoirs or upstream diversions that may divert floodwater outside the basin. Composite effects from works of man including canals, roads, levees, dams, and storage behind fills during floods are difficult to evaluate. Only a few floods have been measured in channels of this type and most of these have been on large streams.

Flows in Robbers Roost Creek (13073700), Spring Valley Creek (13207000), Morse Creek (13301800), and Twelve Mile Creek (13302200) in Table B-3 are known to be affected by diversions above the gaging sites. Likewise, floods in "D" drain tributary (M13084800), "F" drain, and some others listed in Table B-3 may be affected in varying degrees by works of man.

4. Streams With Losing or Gaining Reaches

A large number of streams, both large and small, gain or lose flow by interaction with the groundwater system. Streams flowing over permeable formations tend to gain in discharge if they are below adjacent groundwater tables and lose if above them. These streams are especially common in the areas marked "undefined" in Figure B-9. The characteristics of floods in such streams can be very different from streams fed more directly by overland flow.

Peaks in gaining reaches may be greatly subdued because all or part of the peak flow originates from groundwater runoff, which is regulated by slowly changing water tables. For example, the discharge of Birch Creek near Reno (Station 13117000) is practically all groundwater runoff that originates a few miles above the gage. The maximum flow in 15 years of record is 220 cfs (Table B-3). This peak flow is only 2.8 times the average discharge for the period of record. The channel is usually dry over the alluvium above the reach of discharge from groundwater. The stream then loses below the gage, never flowing past the Birch Creek Sinks about 30 miles downstream. A more normal stream nearby, Sawmill Creek near Goldburg (13117300), had a maximum flow of 651 cfs in 10 years of records, which is 13.4 times its average flow for the period.

Other streams, such as Cub River near Preston (10093000) and Birch Creek near Downey (13074000), are fed by large underground flows from solution cavities in limestone mountains and respond relatively quickly to changing rates of snowmelt. They may drain areas much larger or smaller than their surface drainage indicates. Flood flows in such streams may be at high rates while the flooding in adjacent streams may be considerably smaller.

A decrease in flood discharge occurs in many small streams as they flow from the impervious rocks of the mountain ranges onto the alluvial valleys. Peak flows are often further decreased by diversion for irrigation. For example, the maximum discharge of record for Morse Creek above diversions near May (13301700) is 230 cfs, while the maximum for Morse Creek near May (13301800), 2.7 miles downstream, across an alluvial fan, and below irrigation diversions, was 81 cfs.

Stream channels known to be affected by significantly large gains or losses are shown in Figure B-9. Data other than or in addition to the discharge determined by regional regression equations are needed in these areas.

5. Alluvial Valleys and the Snake Plain

Closely related to the streams with losing or gaining reaches, discussed previously, are streams draining basins entirely in alluvial or glacial valleys or on the Snake Plain. Other basins include both mountain and valley areas. Large areas of intermontane valleys and lowlands are underlain by deep alluvium. Other areas, especially the Snake Plain, are underlain by fractured basalt, and both types of formation can absorb large quantities of floodwater. Percolation rates are considerably reduced by deep soil cover or by lacustrine deposits, both of which vary considerably in thickness, extent, and permeability.

In most years, floods are not generated on the alluvial valleys and plains because the rate of infiltration greatly exceeds the snowmelt or precipitation rate. Natural streams are ephemeral unless the channel intercepts the groundwater table, in which case the stream is intermittent or perennial. Large parts of the Snake Plain are unchannelized or have very poorly developed channels, indicating that overland flow may be rare and short-lived.

Occasionally as the snow melts, the melt water freezes in place and a glaze is formed over the permeable alluvial or basaltic surfaces, making the surface very impermeable. If more snow accumulates and a quick snowmelt then occurs, high rates of runoff result. The floods of February 1962, February 1963, and December 1964 resulted from this sequence of hydrologic conditions and caused extensive flooding on the lowland areas of southern Idaho. Many miscellaneous measurements of these flood discharges were obtained and are shown within basin boundaries (Figure B-11). The measurement results are listed in Table B-3. No frequency data are available for this type of flood, but the data are indicative of the size of flood that can be expected from this type of event.

Much of the irrigated land in the state is in this area, and natural streams are usually affected by regulation, diversions, return flow, or changing land use (Figure B-9).

6. Intense Thunderstorm-Prone Areas

Intense thunderstorms may produce rates of runoff in small basins that are much higher than those computed using the regression equation. Of the peak discharges listed in Table B-3, those that were summer floods and were not associated with snowmelt were assumed to be caused by intense thunderstorms. Of those, 11 discharges exceeded 1,000 cfsm, of which three were higher than 5,000 cfsm. Five more measurements showed rates between 500 and 1,000 cfsm, 13 showed rates between 500 and 1,000 cfsm, and 13 showed rates between 100 and 500 cfsm. Reference to Figure B-11 and the "Relative Magnitude of Floods" section indicates that most of the extremely high rates of runoff of record in Idaho are caused by intense thunderstorms. Storm cells are often small and may be confined to a small part of the basin.

All of the intense thunderstorm-prone areas measured to date are essentially unforested, except Canyon Creek tributary near Lowman, which is only sparsely forested. Practically all of the extreme floods caused by thunderstorms, which have been documented, are in southern Idaho near the Snake Plane except for a few floods near Lewiston. Areas near the Boise front, in the Portneuf-Bear River section, and near American Falls, Murphy, Bruneau, and Lewiston appear to occur near the foothills or the base of the mountains adjacent to extensive valley areas such as the Snake Plain, Cache Valley, or Columbia Basin.

No series of annual peak flows has been established for any of these intense thunderstorm-produced floods and recurrence intervals have not been established. Probably the best basis for establishment of recurrence intervals at a design site would be from the newspaper or other local accounts. Hazard from this type of flood does exist and should be considered when designing structures for several areas of the state.

7. Anomalous Areas

Variations in topography, geology, climate, and land use are extreme in the state. The basin characteristics determined do not define all combinations of these variables, and the effects of the variables on flood flows have not been defined by the limited number of sites where flow data have been collected. The discharges given by the simplified equations proposed do not fit all the records of discharge within reasonable limits. The actual discharge for a given recurrence interval for some ungaged streams will likewise be more or less than the discharge given by the regression equations of this report.

Table B-4 is a list of the gaged sites for which the Q_{10}, determined by the modified log-Pearson Type III method, exceeds or is less than the Q_{10} from the regression equations by more than 70 percent. Reasons for departures from regional data are not always apparent, but at nearly all sites listed in Table B-4, several flood events have been recorded that exceed or were less than the regional 10- or even 50-year peaks as determined by the applicable regional equations. Reference to Table B-4 will enable users to determine areas where peaks of records are well above or below the estimated discharges using the regional equations.

The percentage of departure of an anomalous area from the regional data can be used as a guide in the application of the regional data to ungaged small streams. Estimates of peak flow for streams within anomalous basins or for nearby basins that appear to have similar flow or basin characteristics can be raised or lowered accordingly, especially if underdesigning or overdesigning would result in extensive damage or prohibitive costs.

Sources of Information

The U.S. Geological Survey publishes streamflow data for Idaho and is the major source of streamflow information. Each volume of the series of Geological Survey water-supply papers entitled "Surface Water Supply of the United States" contains a listing of the numbers of all water-supply papers in which records of surface-water data were published for the area covered by that volume. Each volume also contains a list of water-supply papers that give detailed information on major floods for the area.

Records through September 1950 for the state have been compiled and published in Water-Supply Papers 1314, 1316, and 1317. Records for October 1950 to September 1960 have been compiled and published in Water-Supply Papers 1734, 1736, and 1737. These reports contain summaries of monthly and annual discharge or month-end storage for all previously published records, as well as some records not contained in the annual series of water-supply papers. The yearly summary table for each gaging station lists the numbers of the water-supply papers in which daily records were published for that station.

The new series of water-supply papers containing daily surface-water records for the 5-year period from October 1, 1960 to September 31, 1965 (Water-Supply Papers 1927, 1933, and 1935) also contain lists of annual and special reports published as water-supply papers.

Records since October 1, 1965, are published in annual volumes entitled "Water Resources Data for Idaho."

Discharge measurements made at miscellaneous sites and peak discharges at partial-record stations are compiled for the period 1894-1967 in a special basic-data report, "Miscellaneous Streamflow Measurements in Idaho, 1894-1967."

Special reports on major floods or droughts or other hydrologic studies for the area have been issued in publications other than water-supply papers. Information relative to these reports may be obtained from the U.S. Geological Survey.

GAGING STATIONS AT WHICH THE Q_{10} IS DETERMINED BY THE MODIFIED log-PEARSON METHOD DIFFERS BY MORE THAN 70 % FROM THE Q_{10} DETERMINED BY THE REGIONAL EQUATION

	Station No.	Station Name	Difference (percent)
2	13302200	Twelvemile Creek near Salmon	-72
2	13336100	Meadow Creek near Lowell	206
2	13348400	Missouri Flat Creek Tributary near Pullman, WA	208
3	13154000	Clover Creek near Bliss	97
3	13155000	King Hill Creek near King Hill	142
3	13238300	Deep Creek near McCall	203
3	13240000	Lake Fork above Jump Creek, near McCall	80
3	13240500	Lake Fork above reservoir, near McCall	75
3	13249000	Squaw Creek near Gross	214
3	13290150	North Fork Pine Creek near Homestead, OR	218
3	13335200	Critchfield Draw near Clarkston, WA	156
4	13172680	Reynolds Creek Station W4	143
4	13172725	Reynolds Creek Station W12	323
4	13172730	Reynolds Creek Station W11	121
4	13172740	Reynolds Creek Station W1	135
4	13235100	Rock Creek at Lowman	137
5	13293000	Alturas Lake Creek near Obsidian	96
5	13297300	Holman Creek near Clayton	-75
5	13298300	Malm Gulch near Clayton	364
6	13027200	Bear Canyon near Freedom	130
6	13057600	Homer Creek near Herman	85
7	13075700	South Fork Pocatello Creek near Pocatello	-70
7	10084500	Cottonwood Creek near Cleveland	122
7	10090800	Battle Creek Tributary near Teasureton	164
7	10096500	Maple Creek near Franklin	98
7	10099000	High Creek near Richmond	120
7	13062700	Angus Creek near Henry	262
8	13161300	Meadow Creek near Rockland, NV	106
8	13162200	Jarbridge River at Jarbridge, NV	120

Gaging Station Numbering System

Each gaging station and partial-record station has been assigned a number in downstream order in accordance with the permanent numbering system used by the U.S. Geological Survey. Numbers are assigned in a downstream direction along the main stream, and stations on tributaries between mainstream stations are numbered in the order they enter the main stream. A similar order is followed on other ranks of tributaries. The complete 8-digit number, such as 13038900, includes the part number "13" plus a 6-digit station number. Miscellaneous measurement sites are designated by the letter "M" preceding the station number.

B.40.04*Using Channel Geometry to Estimate Flood Flows at Ungaged Sites in Idaho* by U.S. Geological Survey; Water-Resources Investigations 80-32. The following is a summary of a portion of this report: Equations using Q_{200} and Q_{500} as dependent variables are not presented because of the uncertainties associated with extending the frequency curve too far. Most of the gaging stations used have less than 25 years of record.

Application to Ungaged Sites

Use following procedure for bankfull width to estimate peak discharges at ungaged sites:

1. At the site of interest, make 5 to 10 measurements of bankfull width and average them. The measurements should be at least a channel width apart and at the level of bankfull discharge. Riggs (1974), in describing his whole-channel section, said, "The reference level for this section is variously defined by breaks in bank slope, by the edges of the flood plain, or by the lower limits of permanent vegetation." Wahl (1977) pointed out that on perennial streams, this is virtually the same as bankfull stage as described by Leopold, Wolman, and Miller (1964). More detailed descriptions are available in Emmett (1975) and Lowham (1976).

2. Use either of the sets of equations below to solve an estimate of the peak of interest:

$Q_{1.25} = 0.43\ WB^{1.78}$ SE = 98%, -49%
$Q_{2} = 0.76\ WB^{1.73}$ SE = 92%, -48%
$Q_{5} = 1.31\ WB^{1.68}$ SE = 90%, -47%
$Q_{10} = 1.73\ WB^{1.66}$ SE = 90%, -47%
$Q_{25} = 2.29\ WB^{1.64}$ SE = 92%, -48%
$Q_{50} = 2.73\ WB^{1.62}$ SE = 93%, -48%
$Q_{100} = 3.21\ WB^{1.61}$ SE = 95%, -49%

or:
$Q_{1.25} = 0.48\ AREA^{0.33}\ (I24\_2)^{1.21}\ WB^{1.22}$ SE = 79%, -44%
$Q_{2} = 0.94\ AREA^{0.34}\ (I24\_2)^{1.06}\ WB^{1.16}$ SE = 74%, -42%
$Q_{5} = 1.74\ AREA^{0.35}\ (I24\_2)^{0.93}\ WB^{1.10}$ SE = 72%, -42%
$Q_{10} = 2.37\ AREA^{0.35}\ (I24\_2)^{0.86}\ WB^{1.07}$ SE = 73%, -42%
$Q_{25} = 3.24\ AREA^{0.36}\ (I24\_2)^{0.81}\ WB^{1.03}$ SE = 75%, -43%
$Q_{50} = 3.92\ AREA^{0.37}\ (I24\_2)^{0.78}\ WB^{1.01}$ SE = 77%, -43%
$Q_{100} = 4.65\ AREA^{0.37}\ (I24\_2)^{0.78}\ WB^{.99}$ SE = 79%, -44%

The first set of equations requires that only WB be measured to make an estimate of the selected peak discharge(s). The second set requires that AREA and I24_2 also be obtained. The second set is included because the estimated peaks may be better estimates, as indicated by the lower standard error.

If the second set of equations is used, an estimate of I24_2 must be made. The map on Figure B-12 (three sheets) can be used to determine the correct value for each drainage basin of interest. The drainage basin should be located on the map and an average value of I24_2 selected.

Definitions

AREA – Drainage area in square miles.

I24_2 – Precipitation intensity in inches for a 24-hour period with a recurrence interval of 2 years.

$Q_{1.25}$ – Peak discharge in cubic feet per second with a recurrence interval of 1.25 years.

Q_2 to Q_{100} – Peak discharges for recurrence intervals of 2 to 100 years.

SE – Standard error in percent. The two figures following SE show the plus and minus percentages and the result because variables were computed in logarithmic form.

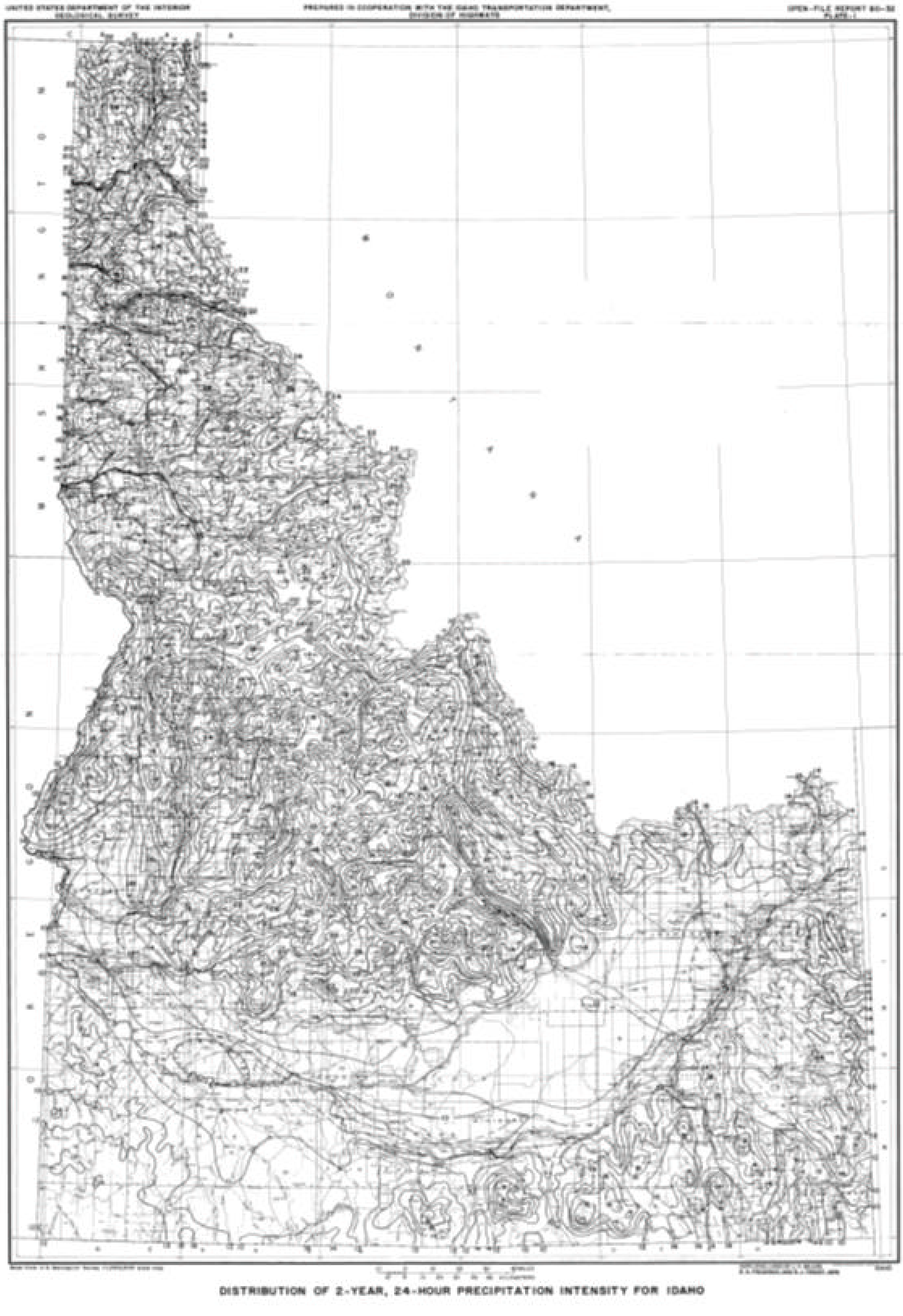
WB – Width of water surface at bankfull stage (average of 5 to 10 field measurements).

Conclusions

The study shows that estimates of flood flows can be made at ungaged sites in Idaho by using regression equations that relate selected floods to bankfull width or bankfull area.

The study indicates that estimates of flood flow made by using channel measurements as the independent variable are slightly better than estimates made by using basin characteristics as the independent variable. It also indicates that estimates made by using both basin and channel characteristics as the independent variables are even better.

Figure B-12



DISTRIBUTION OF 2-YEAR, 24-HOUR PRECIPITATION INTENSITY FOR IDAHO

B.40.05 *A Method of Estimating Flood-Frequency Parameters for Streams in Idaho* by U.S. Geological Survey, Open-File Report 81-909.

> If calculations are for a metric project, final Q values obtained from hydrology calculations, U.S. Geological Survey regression equations, nomographs, charts, etc., should be converted from cubic feet per second to cubic meters per second.

The following is a summary of a portion of this report: The report was modified for ITD projects with forest cover between 0 and 30 percent. It was discovered that abnormally high results were obtained for watersheds with a low percentage of forest cover. Details are shown in Figure B-13. The revision was reviewed and concurred with by L. C. Kjelstrom and W. A. Harenberg of the U.S. Geological Survey.

Flood-Frequency Analysis for Ungaged Sites

Estimates of the most important statistic of the log-Pearson Type III distribution – the mean logarithm of annual peak discharges – can be predicted by basin characteristics. If reasonable estimates of the standard deviation of logarithms of annual peak discharges, which ranged from 0.084 to 0.538, could also be predicted by basin characteristics, the log-Pearson Type III equation could be used to develop a frequency curve for ungaged sites. Because generalized skew coefficients seem to give reasonable results when used directly for the 120 stations having less than 25 years of record, the generalized skew maps can also provide estimates of skew for ungaged basins. Regression analyses of the mean and standard deviations of logarithms of annual peaks with basin characteristics were made using 269 gaging stations (Figure B-14) having 10 or more years of systematic record.

After investigating several methods, it was determined that the two statistics could best be predicted by: (1) regionalizing the data on the basis of significant basin characteristics, for example, drainage area, mean altitude, and mean annual precipitation; and (2) separating the regionalized data by basin size. The comparison of various regression equations, correlation coefficients, and computer plots of dependent and independent variables aided in defining the regions and drainage basin sizes in some cases where different sets of variables were effective. Some subjective judgment was necessary to make the finer distinctions, but the division into subareas and drainage size was largely dictated from analyzing the data. For this study, the area was divided into three regions on the basis of similarity of basin characteristic effect; each region was analyzed separately (Figure B-15).

For both the mean and standard deviation in region 1 and the standard deviations in regions 2 and 3, a separation of basin size was required because of changes in statistically significant basin characteristics. Regression equations for region 1 could not be defined for drainage basins greater than 250 square miles because nearly all larger basins are affected by diversions or regulation. Multiple regression was done by using stepwise and step-backward techniques. Regression equations (Figure B-13) with two or three independent variables were selected on the basis of coefficients of determination, correlation coefficients, and statistical tests. The form of the equations remains in logarithmic units so an estimate of the statistics can be used in the log-Pearson Type III equation.

Regionalized Regression Equations for Annual Maximum Discharges

Region	See Figure 6 for division of Regions.	MAP	Mean Annual Precipitation.
DA	Drainage Area, in square miles.	ALT	Mean Altitude of the Basin.
S	Average Slope of Main Channel between points at 85 and 10 percent of the length above the gage to the basin divide. Units are feet per mile.	INT24HR	Rainfall Intensity of a 24-hour period at the 50 percent exceedance probability.
F	Percentage of Forest Cover plus 1 percent.	MMJT	Mean Minimum January Temperature.

MODIFICATION FOR USE ON ITD PROJECTS

1. Delete -0.157xlogF (as shown) from appropriate equations in Regions 2 & 3 (DA greater than 250 square miles.)
2. Multiply computed Q by Forest Factor, defined below, when calculated from these same two equations.

PERCENT FOREST = 0-30	PERCENT FOREST = 30-100
Forest Factor = $\dfrac{(10^{(-0.157xKxlog\ 30)}-10^{(-0.157xKxlog\ 32)})(31-F)}{2} + 10^{(-0.157xKxlog\ 30)}$	Forest Factor = $10^{(-0.157xKxlog\ F)}$

Region	Drainage area (mi)	**M = MEAN LOG** Regression equation for mean logarithm of annual maximum discharges	**S = STANDARD DEVIATION** Regression equation for standard deviation of logarithms of annual maximum discharges	**Q = DISCHARGE** **K = FREQUENCY FACTOR** for log-Pearson Type III distribution, determined from Skew & desired frequency
1	$\leq$35	1.477 + 1.280 log DA - 0.399 log S	3.289 – 0.175 log DA – 0.739 log ALT	$Q = 10^{(M + KS)}$
	>35 to <250	0.637 + 0.808 log DA + 0.155 log F	3.250 - 0.083 log F - 0.732 log ALT - 0.523 log INT24HR	$Q = 10^{(M + KS)}$
2	$\leq$250	-0.037 + 0.839 log DA + 0.834 log MAP	1.877 - 0.067 log DA - 0.193 log MAP - 0.337 log ALT	$Q = 10^{(M + KS)}$
	>250	-0.037 + 0.839 log DA + 0.834 log MAP	0.600 – 0.157 log F –0.123 log MAP + 0.060 log MMJT	$Q = (\text{Forest Factor})(10^{(M + KS)})$
3	$\leq$250	0.800 + 0.993 log DA + 0.169 log S	0.751 - 0.050 log DA - 0.111 log ALT - 0.057 log MAP	$Q = 10^{(M + KS)}$
	>250	0.800 + 0.993 log DA + 0.169 log S	0.600 – 0.157 log F – 0.123 log MAP + 0.060 log MMJT	$Q = (\text{Forest Factor})(10^{(M + KS)})$

Figure B-14

sheet 1 of 5

Data Table D. -- Magnitude and frequency of flood data for selected gaging stations using the log-Pearson Type III distribution - Continued

		Discharge, in ft³/s							
STA_NO	STA_NAME	_50 PCT	_10 PCT	_4 PCT	_2 PCT	_1 PCT	MAX_PEAK	DATE	YRS_REC
13113000	BEAVER C AT SPENCER, ID	321	578	712	803	906	1190	05-18-75	21
13116000	MEDICINE LODGE C AT ELLIS RCH NR ARGORA, ID	105.0	192	241	279	320	361	04-15-62	31
13117000	BIRCH C NR RENO, ID	100.0	125	137	145	154	320	04-01-62	16
13117200	MAIN FORK NR GOLDBURG, ID	134.0	238	288	324	-	373	06-12-65	18
13117300	SAWMILL C NR GOLDBURG, ID	364.0	658	788	888	-	651	06-12-65	13
13118700	LITTLE LOST R BLW WET C NR HOWE, ID	207.0	498	574	652	687	609	06-16-75	17
13120000	NF BIG LOST R AT WILD HORSE NR CHILLY, ID	735.0	1158	1380	1500	1658	1420	06-12-65	34
13120500	BIG LOST R AT HOWELL RANCH NR CHILLY, ID	2120.0	3408	3830	4290	4628	4420	05-25-67	74
13120900	LOWER CEDAR C AB DIVERSIONS NR MACKAY, ID	155.0	247	289	318	-	256	06-08-72	11
13135200	PRAIRIE C NR KETCHUM, ID	167.0	285	314	358	-	293	05-24-63	18
13135500	BIG WOOD R NR KETCHUM, ID	891.0	1438	1690	1870	2058	1990	05-24-67	26
13135800	ADAMS GULCH DR KETCHUM, ID	40.0	113	161	199	-	124	1971	18
13141400	DEER C NR FAIRFIELD, ID	54.0	112	147	175	-	150	04-03-65	11
13141500	CAMAS C NR BLAINE, ID	2650.0	7158	9730	11708	13608	8780	04-08-43	53
13145700	SCHOOLER C NR GOODING, ID	23.0	55	76	93	112	68	02-01-63	16
13147900	LITTLE WOOD R AB HIGH FIVE C NR CAREY, ID	830.0	1808	2450	3208	4508	3800	12-22-55	41
13154000	CLOVER C NR BLISS, ID	1410.0	5168	8640	12200	16808	11800	12-22-64	28
13155200	BURNS GULCH NR GLENNS FERRY, ID	5.3	17	27	35	-	22	02-01-63	18
13155300	L CANYON C AT STOUT XING NR GLENNS FERRY, ID	88.0	238	338	438	555	500	12-23-64	15
13161100	BRUNEAU R NR CHARLESTON, NV	200.0	183	494	678	1088	1890	02-11-62	15
13161200	SEVENTY SIX C NR CHARLESTON, NV	24.0	74	108	136	168	89	05-08-75	15
13161300	MEADOW C NR ROWLAND, NV	188.0	533	1010	1380	1828	840	06-04-63	15
13161500	BRUNEAU R NR ROWLAND, NV	710.0	1588	2130	2590	3108	2120	02-11-62	22
13161600	MCDONALD C NR ROWLAND, NV	43.0	78	95	109	124	85	06- -75	16
13162200	JARBIDGE R AT JARBIDGE, NV	299.0	606	790	948	-	700	06- -78	15
13162400	BUCK C NR JARBIDGE, NV	79.0	261	410	558	-	380	06- -71	16
13162500	E F JARBIDGE R NR THREE CREEK, ID	436.0	735	894	1028	1148	798	06-22-71	22
13162600	COLUMBET C NR JARBIDGE, NV	11.0	35	52	69	88	46	05- -75	16
13167500	E F BRUNEAU R NR HOT SPRING, ID	394.0	468	687	861	1068	619	06-08-63	27
13168500	BIG JACKS C NR BRUNEAU, ID	362.0	712	1390	1948	2818	3100	01-22-43	23
13170000	L JACKS C NR BRUNEAU, ID	138.0	758	1430	2180	-	908	01-21-43	11
13170100	SUGAR C TRIBUTARY NR GRASMERE, ID	24.0	83	131	177	233	105	06-10-69	17
13172666	WEST FORK REYNOLDS C NR REYNOLDS, ID	4.7	13	20	25	-	14	08-02-75	14
13172668	EAST FORK REYNOLDS C NR REYNOLDS, ID	4.0	9	13	16	-	11	04-29-65	16
13172680	REYNOLDS C AT TOLLGATE WEIR NR REYNOLDS, ID	207.0	303	355	398	-	404	05-10-69	13
13172720	MACKS C NR REYNOLDS, ID	89.0	345	566	780	-	1300	12-23-64	15
13172735	SALMON C NR REYNOLDS, ID	75.0	268	429	580	-	1810	12-23-64	15
13172740	REYNOLDS C AT OUTLET WEIR NR REYNOLDS, ID	414.0	1468	2310	3130	-	3800	12-23-64	16
13172800	L SQUAW C TRIBUTARY NR MARSING, ID	9.0	45	80	117	169	93	01-31-63	17
13178000	JORDAN C AB LONE TREE C NR JORDAN VALLEY, OR	2850.0	3808	5080	6040	7478	7530	12-24-64	28
13184200	ROARING R NR ROCKY BAR, ID	326.0	537	635	704	-	575	06-22-67	14
13184800	BEAVER C NR LOWMAN, ID	102.0	182	224	257	-	195	1971	18
13185000	BOISE R NR TWIN SPRINGS, ID	7300.0	11308	13580	15008	16808	22700	1872	67
13186000	S F BOISE R NR FEATHERVILLE, ID	4550.0	6048	7280	7958	8498	7580	05-24-56	32
13186500	LIME C NR BENNETT, ID	649.0	1188	1470	1698	-	3180	04-27-52	11
13187800	FALL C NR ANDERSON RANCH DAM, ID	521.0	858	998	1128	-	3150	04-27-52	12
13191800	S F BOISE R NR LENOX, ID	4800.0	8548	10580	12080	13608	9550	04-17-43	35
13196500	BANNOCK C NR IDAHO CITY, ID	15.0	34	47	59	72	46	04-22-65	28
13200000	MORES C AB ROBIE CR NR ARROWROCK DAM, ID	2800.0	3808	5180	6080	7108	5370	04-08-43	62
13200500	ROBIE C NR ARROWROCK, ID	69.0	135	179	215	256	274	01-29-65	21
13207000	SPRING VALLEY C NR EAGLE, ID	51.0	241	442	663	-	435	02-11-79	16
13207500	DRY C NR EAGLE, ID	95.0	386	649	908	-	375	01-29-65	14
13210300	BRYANS RUN NR BOISE, ID	67.0	217	334	440	565	420	01-16-71	19
13214000	MALHEUR R NR DREWSEY, OR	2880.0	5408	8880	11108	14908	12800	12-23-64	57

Data Table D. – Magnitude and frequency of flood data for selected gaging stations using the log-Pearson Type III distribution - Continued

STA_NO	STA_NAME	Discharge, in ft³/s _50_PCT	_10_PCT	_4_PCT	_2_PCT	_1_PCT	MAX_PEAK	DATE	YRS_REC
12413200	MONTGOMERY C NR KELLOGG, ID	72	168	218	288	-	155	01-31-71	18
12413500	COEUR D'ALENE NR CATALDO, ID	18800	36700	51500	69000	90100	79800	01-16-74	54
12413700	LATOUR C NR CATALDO, ID	808	1140	1450	1700	-	1800	01-16-74	18
12414500	ST. JOE R AT CALDER, ID	16400	26200	32200	38400	45400	53900	12-23-33	59
12414900	ST. MARIES R NR SANTA, ID	2470	5450	7370	8980	-	10700	01-15-74	13
12415000	ST. MARIES R AT LOTUS, ID	4780	10900	15200	19000	23500	23800	12-22-33	44
12415100	CHERRY C NR ST. MARIES, ID	115	198	245	283	-	317	01-16-74	12
12415200	PLUMMER C TRIB AT PLUMMER, ID	67	115	140	161	182	150	01-15-74	16
12416000	HAYDEN C BW NORTH FORK, NR HAYDEN LAKE, ID	228	644	825	988	1120	790	12-23-64	23
12424000	HANGMAN C AT SPOKANE, WA	7370	14100	18400	21900	25600	28800	02-03-63	38
12427000	LITTLE SPOKANE R AT ELK, WA	108	148	169	184	193	205	01-16-74	28
12431000	LITTLE SPOKANE R AT DARTFORD, WA	1490	2360	2880	3130	3460	3170	02-17-78	35
12465000	CRAB C AT IRBY, WA	1120	4310	7870	9720	12900	8370	02-27-57	35
13011500	PACIFIC C AT MORAN, WY	2450	3300	3650	3880	4090	3790	06-15-74	31
13011900	BUFFALO FORK AB LAVA C, NR MORAN, WY	4250	5200	5570	5810	-	6820	06-19-74	12
13014500	GROS VENTRE R AT KELLY, WY	3300	4590	5290	5790	-	8960	06-16-18	15
13022000	GREYS R ABOVE RES. NR ALPINE, WY	3420	5280	6310	6690	7240	7230	06-19-71	28
13024500	COTTONWOOD C NR SMOOT, WY	243	368	411	445	479	438	06-02-58	25
13025000	SWIFT C NR AFTON, WY	506	718	795	853	907	795	07-06-75	38
13025500	CROW C NR FAIRVIEW, WY	227	334	379	411	-	346	02-01-63	18
13027500	SALT R ABOVE RES. NR ETNA, WY	2140	3510	4130	4570	4980	3870	06-01-71	22
13028500	MCCOY C ABOVE RES. NR ALPINE, ID	815	1330	1500	1610	1720	1670	05-10-74	19
13030000	INDIAN C ABOVE RES. NR ALPINE, ID	207	304	345	375	408	350	06-14-18	18
13030500	ELK C ABOVE RES. NR IRWIN, ID	476	702	799	866	928	870	05-15-18	18
13032000	BEAR C ABOVE RES. NR IRWIN, ID	521	754	853	928	983	784	05-05-36	22
13038900	TARGHEE C NR MACKS INN, ID	274	379	423	452	479	458	05-23-78	15
13044500	WARM R AT WARM RIVER, ID	467	728	846	928	1000	900	05-02-32	18
13045500	ROBINSON C AT WARM RIVER, ID	596	990	1180	1520	1440	1140	05-28-32	18
13047500	FALL R NR SQUIRREL, ID	3480	4790	5370	4770	6150	6490	06-27-27	65
13050700	MAIL CABIN C NR VICTOR, ID	39	58	65	74	-	81	05-21-71	18
13050800	MOOSE C NR VICTOR, ID	281	371	407	431	-	390	06-23-71	18
13052200	TETON R ABOVE SLEIGH C NR DRIGGS, ID	1390	2030	2250	2500	2800	2370	05-19-74	22
13054400	MILK C NR TETONIA, ID	302	519	891	1250	1670	1350	02-01-53	16
13055000	TETON R NR ST. ANTHONY, ID	5260	5270	6320	7120	7940	11800	02-12-52	67
13058000	WILLOW C NR RIRIE, ID	1720	3150	3890	4490	5100	5800	02-11-62	25
13061100	SNAKE R TRIB NR OSGOOD, ID	89	338	540	747	1000	450	01-21-69	17
13062700	ANGUS C NR HENRY, ID	266	667	886	1100	-	1060	05-11-78	13
13063000	BLACKFOOT R. ABOVE RES. NR HENRY, ID	1260	2140	2550	2840	3120	2150	04-26-74	22
13063500	L BLACKFOOT R AT HENRY, ID	145	254	307	346	-	392	04-19-34	12
13068500	BLACKFOOT R. NR BLACKFOOT, ID	1650	2650	3130	3490	3840	3500	05-01-52	55
13073700	ROBBERS ROOST C NR MCCAMMON, ID	13	27	35	42	-	24	04-22-69	11
13075000	MARSH C NR MCCAMMON, ID	294	476	585	680	788	1120	02-12-62	23
13075600	NF POCATELLO C NR POCATELLO, ID	21	46	62	75	-	57	03-15-71	11
13077700	GEORGE C NR YOST, UT	66	118	131	146	168	146	06-10-63	18
13078000	RAFT R AT PETERSON RH NR BRIDGE, ID	130	458	828	1390	2270	2860	01-17-71	24
13079000	CLEAR C NR NAF, ID	121	226	278	317	355	386	06-15-67	28
13079200	CASSIA C NR ELBA, ID	165	458	642	827	-	982	12-23-64	11
13079800	HEGLAR CANYON TRIBUTARY NR ROCKLAND, ID	117	396	652	916	1200	1930	07- -58	18
13082500	GOOSE C AB TRAPPER NR OAKLEY, ID	300	818	1260	2140	3200	3240	02-11-62	64
13083000	TRAPPER C NR OAKLEY, ID	58	105	142	175	216	370	08-17-41	61
13092000	ROCK C NR ROCK CREEK, ID	197	428	538	625	712	401	05-19-78	38
13105000	SALMON FALLS C NR SAN JACINTO, NV	760	1560	2280	3000	4300	3430	05-18-75	65
13108500	CAMAS C AT 18 M SHEARING CORRAL NR KILGORE, ID	870	1640	2030	2310	2590	2590	05-08-69	28
13112900	HUNTLEY CANYON AT SPENCER, ID	10	23	30	36	-	36	05-15-69	18

Data Table D. – Magnitude and frequency of flood data for selected gaging stations using the log-Pearson Type III distribution - Continued

STA_NO	STA_NAME	Discharge, in ft³/s _50_PCT	_10_PCT	_4_PCT	_2_PCT	_1_PCT	MAX_PEAK	DATE	YRS_REC
13113000	BEAVER C AT SPENCER, ID	321	578	702	803	906	1190	05-18-75	21
13116000	MEDICINE LODGE C AT ELLIS RCH NR ARGORA, ID	105.0	192	241	279	328	361	04-15-62	31
13117000	BIRCH C NR RENO, ID	100.0	125	137	145	154	220	04-01-62	16
13117200	MAIN FORK NR GOLDBURG, ID	134.0	238	288	324	*	273	06-12-65	18
13117300	SAWMILL C NR GOLDBURG, ID	364.0	658	788	888	*	851	06-12-65	12
13118700	LITTLE LOST R BLW WET C NR HOWE, ID	307.0	498	574	632	687	609	06-16-75	17
13120000	NF BIG LOST R AT WILD HORSE NR CHILLY, ID	733.0	1150	1380	1500	1658	1420	06-12-65	34
13120500	BIG LOST R AT HOWELL RANCH NR CHILLY, ID	2120.0	3400	3930	4290	4628	4420	05-25-67	74
13120900	LOWER CEDAR C AB DIVERSIONS NR MACKAY, ID	155.0	247	289	318	*	256	06-08-72	11
13135200	PRAIRIE C NR KETCHUM, ID	167.0	285	314	388	*	293	05-24-63	18
13135500	BIG WOOD R NR KETCHUM, ID	891.0	1438	1690	1870	2058	1690	05-24-67	26
13135800	ADAMS GULCH DR KETCHUM, ID	40.0	113	161	199	*	124	1971	18
13141400	DEER C NR FAIRFIELD, ID	54.0	112	147	175	*	150	04-03-65	11
13141500	CAMAS C NR BLAINE, ID	2650.0	7158	9720	11708	13608	8780	04-08-43	53
13145700	SCHOOLER C NR GOODING, ID	23.0	55	76	93	112	68	02-01-63	18
13147900	LITTLE WOOD R AB HIGH FIVE C NR CAREY, ID	830.0	1808	2450	3208	4508	3800	12-22-55	41
13154000	CLOVER C NR BLISS, ID	1410.0	5168	8840	12200	16808	11800	12-22-64	28
13155200	BURNS GULCH NR GLENNS FERRY, ID	5.3	17	27	35	*	22	02-01-63	18
13155300	L CANYON C AT STOUT XING NR GLENNS FERRY, ID	88.0	238	338	438	555	500	12-23-64	15
13161100	BRUNEAU R NR CHARLESTON, NV	200	183	484	678	1088	1890	02-11-62	15
13161200	SEVENTY SIX C NR CHARLESTON, NV	24.0	74	108	136	168	89	05-00-75	15
13161300	MEADOW C NR ROWLAND, NV	168.0	532	1010	1380	1828	840	06-04-63	15
13161500	BRUNEAU R NR ROWLAND, NV	710.0	1588	2130	2590	3108	2120	02-11-62	22
13161600	MCDONALD C NR ROWLAND, NV	43.0	76	95	109	124	85	06- -75	16
13162200	JARBIDGE R AT JARBIDGE, NV	299.0	606	790	948	*	700	06- -78	15
13162400	BUCK C NR JARBIDGE, NV	79.0	261	410	558	*	380	06- -71	16
13162500	E F JARBIDGE R NR THREE CREEK, ID	436.0	735	894	1028	1148	798	06-22-71	22
13162600	COLUMBET C NR JARBIDGE, NV	11.0	35	52	68	88	46	05- -75	16
13167500	E F BRUNEAU R NR HOT SPRING, ID	394.0	498	687	861	1068	619	06-08-63	27
13168500	BIG JACKS C NR BRUNEAU, ID	362.0	712	1390	1948	2818	3100	01-22-43	23
13170000	L JACKS C NR BRUNEAU, ID	330.0	756	1430	2180	*	903	01-21-43	11
13170100	SUGAR C TRIBUTARY NR GRASMERE, ID	24.0	83	131	177	233	105	06-10-69	17
13172666	WEST FORK REYNOLDS C NR REYNOLDS, ID	4.7	12	20	25	*	14	08-02-75	14
13172668	EAST FORK REYNOLDS C NR REYNOLDS, ID	4.0	9	13	16	*	11	04-20-65	16
13172680	REYNOLDS C AT TOLLGATE WEIR NR REYNOLDS, ID	207.0	307	355	398	*	404	05-10-69	13
13172720	MACKS C NR REYNOLDS, ID	89.0	345	596	780	*	1300	12-23-64	15
13172735	SALMON C NR REYNOLDS, ID	75.0	268	429	580	*	1810	12-23-64	15
13172740	REYNOLDS C AT OUTLET WEIR NR REYNOLDS, ID	414.0	1468	2310	3130	*	3800	12-23-64	16
13172800	L SQUAW C TRIBUTARY NR MARSING, ID	9.0	45	80	117	169	93	01-31-63	17
13178000	JORDAN C AB LONE TREE C NR JORDAN VALLEY, OR	2850.0	3808	5800	6040	7478	7530	12-24-64	24
13184200	ROARING R NR ROCKY BAR, ID	326.0	557	635	704	*	575	06-22-67	14
13184800	BEAVER C NR LOWMAN, ID	102.0	182	224	257	*	195	1971	18
13185000	BOISE R NR TWIN SPRINGS, ID	7200.0	11308	13580	15008	16808	22700	1872	67
13186000	S F BOISE R NR FEATHERVILLE, ID	4550.0	6548	7280	7958	8498	7580	05-24-56	32
13186500	LIME C NR BENNETT, ID	649.0	1188	1470	1698	*	3180	04-27-52	11
13187000	FALL C NR ANDERSON RANCH DAM, ID	521.0	858	898	1128	*	3150	04-27-52	12
13191000	S F BOISE R NR LENOX, ID	4800.0	8548	10580	12080	13608	9550	04-17-43	35
13196500	BANNOCK C NR IDAHO CITY, ID	15.0	39	47	59	72	46	04-22-65	28
13200000	MORES C AB ROBIE CR NR ARROWROCK DAM, ID	2800.0	3808	5180	6080	7108	5270	04-08-43	62
13200500	ROBIE C NR ARROWROCK, ID	69.0	135	179	215	254	274	01-29-65	21
13207000	SPRING VALLEY C NR EAGLE, ID	51.0	241	442	663	*	435	02-11-79	18
13207500	DRY C NR EAGLE, ID	95.0	388	649	908	*	375	01-29-65	14
13210300	BRYANS RUN NR BOISE, ID	67.0	217	334	440	565	420	01-16-71	19
13214000	MALHEUR R NR DREWSEY, OR	2830.0	5408	8880	11108	14908	12800	12-23-64	57

Data Table D. – Magnitude and frequency of flood data for selected gaging stations using the log-Pearson Type III distribution - Continued

		Discharge, in ft³/s							
STA_NO	STA_NAME	_50_PCT	_10_PCT	_4_PCT	_2_PCT	_1_PCT	MAX_PEAK	DATE	YRS_REC
13216500	NF MALHEUR R AB BEULAH RES NR BEULAH, OR	860.0	1900	2810	4000	5360	5910	03-20-18	41
13226500	BULLY C AT WARMSPRINGS NR VALE, OR	1230.0	4350	6810	9540	12800	12800	02-24-57	53
13234300	FIVEMILE C NR LOWMAN, ID	345.0	253	312	358	*	520	06-17-74	14
13235000	S F PAYETTE R AT LOWMAN, ID	4220.0	6010	6700	7510	7810	8980	06-16-74	37
13235100	ROCK C AT LOWMAN ID	350.0	318	404	408	*	400	05-13-71	18
13237300	DANSKIN C NR GRIMES PASS, ID	34.0	68	90	108	*	71	04-23-69	16
13238300	DEEP C NR MCCALL, ID	349.0	490	553	597	*	540	06-06-78	16
13240800	LAKE FORK PAYETTE R AB JUMBO C NR MCCALL, ID	1360.0	3120	2460	2690	2910	2770	06-26-71	52
13245400	TRIPOD C AT SMITHS FERRY, ID	84.0	108	183	237	*	183	1971	16
13246900	COTTONWOOD C NR HORSESHOE BEND, ID	68.0	178	244	311	*	303	02-01-63	17
13250800	BIG WILLOW C NR EMMETT, ID	814.0	1490	1860	2150	2450	2100	12-22-64	18
13250650	FOURMILE C NR EMMETT, ID	90.0	367	578	704	*	500	12-22-64	16
13251300	W BRANCH WEISER R NR TAMARACK, ID	38.0	74	94	110	128	87	05-04-71	18
13251500	WEISER R AT TAMARACK, ID	480.0	800	945	1060	1200	1320	12-22-55	37
13252500	EF WEISER R NR COUNCIL, ID	56.0	71	76	80	*	77	06-16-18	18
13253500	WEISER R AT STARKEY, ID	892.0	1940	2400	2920	*	3800	12-22-55	13
13257000	MF WEISER R NR MESA, ID	778.0	1290	1540	1720	1890	1710	12-22-55	19
13258500	WEISER R NR CAMBRIDGE, ID	4880.0	9000	9790	11500	12800	18100	12-22-55	58
13260800	PINE C NR CAMBRIDGE, ID	380.0	490	632	737	847	850	02-25-58	24
13261000	LITTLE WEISER R NR INDIAN VALLEY, ID	790.0	1250	1550	1820	2120	1840	02-04-35	38
13263500	WEISER R AB CRANE C NR WEISER, ID	7700.0	13500	16400	19300	22400	19800	12-23-55	68
13266000	WEISER R NR WEISER, ID	9780.0	17500	21600	24700	27900	22500	12-23-55	58
13267000	MANN C NR WEISER, ID	412.0	790	1110	1460	1880	1590	03-27-48	32
13267100	DEER C NR MIDVALE, ID	61.0	152	211	262	*	156	01-27-78	16
13268300	NF BURNT R NR WHITNEY, OR	693.0	1050	1230	1340	*	3190	04-05-71	13
13270800	S F BURNT R ABOVE BARNEY C NR UNITY, OR	75.0	150	190	228	*	186	04-29-65	14
13273000	BURNT R NR HEREFORD, OR	659.0	1440	1890	2240	2610	2220	04-17-43	28
13275500	PPOWDER R NR BAKER, OR	706.0	1290	1580	1800	2010	1850	1921	52
13288200	EAGLE C ABOVE SKULL C NR NEW BRIDGE, OR	2630.0	3230	3850	4310	4780	5310	07-12-75	23
13290150	M PINE C NR HOMESTEAD, OR	72.0	185	262	328	*	226	04-30-65	13
13290190	PINE C NR OXBOW, OR	2740.0	6300	8850	10600	*	7110	02-21-68	13
13292000	IMNAHA R AT IMNAHA, OR	2600.0	4000	6450	8190	31500	18100	01-17-74	48
13292500	SALMON R NR OBSIDIAN, ID	518.0	714	794	849	*	721	05-29-53	12
13293000	ALTURAS LAKE C NR OBSIDIAN, ID	409.0	650	736	789	*	833	06-07-52	12
13295000	VALLEY C AT STANLEY, ID	990.0	1540	1780	1950	2110	2800	05-24-56	56
13295500	SALMON R BELOW VALLEY C AT STANLEY, ID	3650.0	4650	5350	5830	6290	5900	06-17-74	35
13296000	YANKEE FORK SALMON R NR CLAYTON, ID	1480.0	2790	3490	4020	4550	4900	06-17-74	28
13296500	SALMON R BELOW YANKEE FORK NR CLAYTON, ID	5840.0	8170	9530	10500	11300	18500	06-17-74	56
13297300	HOLMAN C NR CLAYTON, ID	9.1	20	25	30	*	25	06-13-65	16
13298000	E F SALMON R NR CLAYTON, ID	1510.0	3900	3630	4160	4710	4820	06-17-74	15
13298300	MALM GULCH NR CLAYTON, ID	85.0	391	672	940	*	440	04-01-69	18
13299000	CHALLIS C NR CHALLIS, ID	260.0	455	552	624	696	872	06-12-65	27
13301700	MORSE C ABOVE DIVERSIONS NR MAY, ID	142.0	220	267	295	*	270	06-16-75	14
13305700	DAHLONEGA C AT GIBBONVILLE, ID	98.0	211	272	319	*	235	1971	18
13305800	HUGHES C NR NORTH FORK, ID	138.0	254	330	268	417	250	01-16-74	17
13306500	PANTHER C NR SHOUP, ID	1780.0	3050	3630	4050	4440	3850	06-16-74	33
13308500	M F SALMON R NR CAPE HORN, ID	1650.0	2510	2890	3150	3390	3320	06-17-74	44
13309000	BEAR VALLEY C NR CAPE HORN, ID	2300.0	3210	3700	4040	4360	3960	05-27-56	38
13310000	BIG CREEK NR BIG CREEK, ID	3340.0	5200	5870	6540	*	5800	06-03-48	14
13310500	S F SALMON R NR KNOX, ID	1040.0	1500	1690	1830	1950	1820	05-27-56	31
13311000	E F SOUTH FORK SALMON R AT STIBNITE, ID	174.0	261	299	328	*	369	05-14-33	14
13311500	EF SOUTH FORK SALMON R NR STIBNITE, ID	256.0	558	698	775	*	783	06-15-33	12
13312000	E F SOUTH FORK SALMON R NR YELLOW PINE, ID	842.0	1370	1550	1670	*	2850	06-14-33	15
13313000	JOHNSON C AT YELLOW PINE, ID	3820.0	4630	5350	5850	6340	6230	06-17-74	48

Data Table D. – Magnitude and frequency of flood data for selected gaging stations using the log-Pearson Type III distribution - Continued

STA_NO	STA_NAME	Discharge, in ft³/s						DATE	YRS_REC
		_50_PCT	_10_PCT	_4_PCT	_2_PCT	_1_PCT	MAX_PEAK		
13313500	SECESH R NR BURGDORF, ID	1410.0	2080	2250	3420	*	3580	06-03-48	18
13314000	S F SALMON R NR WARREN, ID	11600.0	17300	19800	21500	*	23800	05-28-48	12
13315500	MUD C NR TAMARACK, ID	199.0	335	405	458	511	385	04-27-53	26
13316500	LITTLE SALMON R AT RIGGINS, ID	5180	8840	9490	10800	11800	12600	06-17-74	27
13316800	N F SKOOKUMCHUCK C NR WHITE BIRD, ID	128	231	289	335	384	471	06-08-64	12
13317200	JOHNS C NR GRANGEVILLE, ID	97	389	473	621	*	480	01-29-65	12
13319000	GRANDE RONDE R AT LA GRANDE, OR	3290	5900	7700	9600	12000	14100	01-30-65	68
13320000	CATHERINE C NR UNION, OR	764	1190	1380	1520	1660	1740	05-27-48	56
13323600	INDIAN C NR IMBLER, OR	405	637	752	858	*	818	05-27-48	13
13325000	E F WALLOWA R NR JOSEPH, OR	105	190	229	278	319	450	07-25-37	53
13329500	HURRICANE C NR JOSEPH, OR	537	858	1010	1130	1240	1110	06-09-48	55
13330000	LOSTINE R NR LOSTINE, OR	1500	2280	2470	2850	3010	2550	06-16-74	53
13330500	BEAR C NR WALLOWA, OR	912	1400	1630	1800	1970	1730	06-15-74	55
13331500	MINAM R AT MINAM, OR	3280	5100	5900	6620	7360	6260	06-16-74	12
13334700	ASOTIN C BELOW KEARNEY GULCH NR ASOTIN, WA	382	1040	1660	2300	3150	3780	01-15-74	48
13336500	SELWAY R NR LOWELL, ID	26200	39800	45100	49500	53000	48800	05-29-48	49
13336600	SWIFTWATER C NR LOWELL, ID	72	145	180	221	*	150	01-29-65	18
13336650	EF PAPOOSE C NR POWELL RANGER STA, ID	78	125	148	166	*	125	04-20-65	18
13336850	WEIR C NR POWELL RANGER STATION, ID	264	526	677	796	*	580	05-20-64	18
13336900	FISH C NR LOWELL, ID	1630	2480	2700	3020	*	2280	05-20-64	18
13337000	LOCHSA R NR LOWELL, ID	19300	28700	33000	36100	38100	35100	06-08-64	58
13337200	RED HORSE C NR ELK CITY, ID	88	177	220	260	*	280	05-21-64	18
13337500	S F CLEARWATER R NR ELK CITY, ID	1910	3130	3750	4210	4670	4840	06-08-64	38
13337700	PEASLEY C NR GOLDEN, ID	78	169	234	260	*	240	06-08-64	14
13338000	S F CLEARWATER R NR GRANGEVILLE, ID	5030	8140	9860	11200	12700	15800	05-30-17	51
13338200	SALLY ANN C NR STITES, ID	104	292	340	398	*	385	06-08-64	11
13338700	CANAL GULCH C AT PIERCE RANGER STATION, ID	116	230	290	352	*	281	04-20-65	16
13338900	DEER C NR OROFINO, ID	98	306	473	629	*	405	01-29-65	15
13340500	N F CLEARWATER R AT BUNGALOW R S, ID	16300	23800	26100	28400	30700	27400	05-29-48	25
13341000	N F CLEARWATER R NR AHSAHKA, ID	31500	48800	60000	75200	90500	100800	12-23-33	58
13341100	COLD SPRINGS C NR CRAIGMONT, ID	47	155	244	328	429	380	01-29-65	15
13341300	BLOOM C NR BOVILL, ID	55	113	150	158	213	151	12-24-64	18
13343400	E F POTLATCH R NR BOVILL, ID	653	1130	1410	1650	*	1740	12-23-64	12
13341500	POTLATCH C AT KENDRICK, ID	6380	11600	14500	16900	19400	16000	01-29-65	58
13343800	MEADOW C NR CENTRAL FERRY, WA	608	2240	3600	5080	*	2380	09-13-66	13
13344500	TUCANNON R NR STARBUCK, WA	1830	5470	8100	10600	13500	7980	12-22-64	24
13344700	DEEP C TRIBUTARY NR POTLATCH, ID	56	103	130	152	*	157	12-23-64	11
13344800	DEEP C NR POTLATCH, ID	728	1400	1950	2340	*	2330	01-16-74	16
13345000	PALOUSE R NR POTLATCH, ID	3460	6070	7560	8740	*	10100	01-16-74	16
13346100	PALOUSE R AT COLFAX, WA	4620	8550	10800	12700	14600	12600	01-16-74	21
13348000	S F PALOUSE R AT PULLMAN, WA	1050	2010	3750	4770	5970	5800	02-26-48	38
13348500	MISSOURI FLAT C AT PULLMAN, WA	387	813	1130	1390	1720	1580	02-26-48	23
13349210	PALOUSE R BELOW SOUTH FORK AT COLFAX, WA	8750	14400	19300	22500	*	16800	01-16-74	14
13349400	PINE C AT PINE CITY, WA	1920	5800	7400	8500	*	10600	02-03-63	15
13350500	UNION FLAT C NR COLFAX, WA	877	2010	2770	3420	4150	2830	01-29-65	22
13352500	COW C AT HOOPER, WA	134	496	876	1380	1800	1250	02-05-53	17
14010000	S F WALLA WALLA R NR MILTON, OR	783	1490	1940	2320	2730	2530	01-29-65	58
14013000	MILL C NR WALLA WALLA, WA	910	1840	2600	3160	3780	3680	01-29-65	41
14013500	BLUE C NR WALLA WALLA, WA	314	735	1010	1340	1500	1330	01-08-69	31
14016500	E F TOUCHET R NR DAYTON, WA	1100	2310	3090	3750	4480	5450	12-23-64	21
14017500	TOUCHET R NR TOUCHET, WA	3860	8080	10800	13100	15600	15100	1965	13
14018500	WALLA WALLA R NR TOUCHET, WA	7370	15500	20700	25100	30000	33400	12-22-64	28

Descriptions and a brief explanation of computation procedures for the basin characteristics are given below.

1. Drainage Area (DA)

Drainage area is expressed in square miles, is the total area contributing to flood discharge, and is planimetered from U.S. Geological Survey topographic maps.

2. Drainage Area Below 6,000-Foot Altitude (PL6T)

Drainage area below 6,000-foot altitude is expressed as a percentage of the total drainage area and is obtained by outlining the 6,000-foot contour and planimetering the subbasin.

3. Forest Cover (F)

Forest cover is expressed as a percentage of the drainage covered by forests and is obtained by a grid-overlay method. The grid is selected so that approximately 30 intersections are within the basin. The number of intersections within forested areas are then counted and expressed as a percentage of all intersections.

4. Length

Length is the total distance, expressed in miles, along the main channel between the divide and the gage.

5. Slope (S)

Slope is the average fall in the main channel, expressed in feet per mile, in a reach from the 10th to the 85th percentile of the length upstream from the gage.

6. Mean Altitude (ALT)

Mean altitude, expressed in feet, is computed by a grid-overlay method. The grid selected should have at least 20 points inside the basin. (This may not be possible for very small basins.) Altitudes at the intersection points are then averaged.

7. Mean Annual Precipitation (MAP)

Mean annual precipitation, expressed in inches, is computed by a grid-overlay method on a 1930-1957 mean annual precipitation map (National Oceanic and Atmospheric Administration, 1965). The grid selected should have at least 20 points inside the basin. (This may not be possible for very small basins.) Precipitation at the intersection points is then averaged.

8. Precipitation Intensity for 24 Hours With a 50 Percent Exceedance Probability (INT24HR)

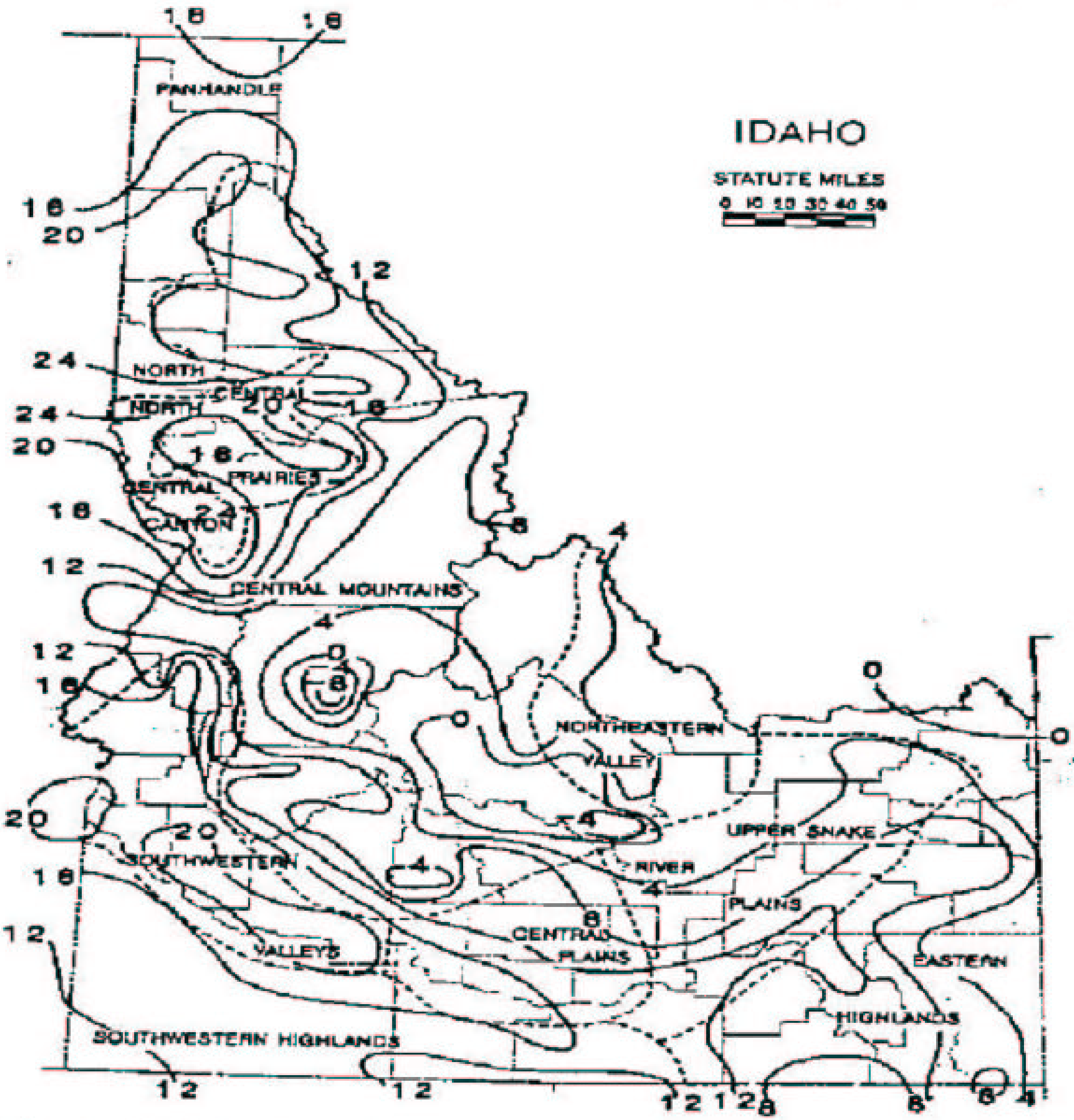
Precipitation intensity, expressed in inches, is computed by using a grid-overlay method and a map of isopluvials of 2-year, 24-hour precipitation (National Oceanic and Atmospheric Administration, 1973, or Harenberg, 1980).

9. Mean Minimum January Temperature (MMJT)

Mean minimum January temperature, expressed in degrees Fahrenheit, is determined from a map (Figure B-16) based on the period 1931-1952 (National Oceanic and Atmospheric Administration, 1971).

Figure B-16

Mean Minimum Temperature (F.), January



Based on period 1931 – 52
Isolines are drawn through points of approximately equal value.
Caution should be used in interpolating on these maps, particularly in mountainous areas.

The regression equations were used to estimate the standard deviation and mean of the logarithms of annual peak discharges for each gaging station in the study area. The generalized skew coefficient previously determined for each station was used to obtain a value for the log-Pearson Type III frequency factor – a function of the skew coefficient and exceedance probability (Bulletin 17A, appendix 3) – at the 2 percent exceedance probability. The log-Pearson equation was then computed and the results were compared with the discharge listed in the data in Figure B-14, based on the gaging-station record. This comparison, which indicates the relative accuracy of the regression equations, is expressed as the standard error of estimate. For a large sample, two out of every three observations can be expected to be within one standard error. The standard error, in percent, for the 2 percent exceedance probability is shown in Figure B-13 for each set of equations. The lost degrees of freedom in computing the standard error were obtained by summing the number of constants in each regression equation and adding one for the skew coefficient.

The regression equations should be used only for streams that have some homogeneity with the streams that defined the equations. Regression equations are not well defined for very small drainage basins and it is not recommended that equations be used for drainage areas less than 0.5 square miles. Also, the regression equations are poorly defined in a range of about 1,500 to 2,000 square miles and are undefined above that range. The regression equations would not apply to streams that are ephemeral, that are subject to intensive thunderstorms, or that drain areas significantly affected by man's activities. Streams that drain unforested basins or that flow through alluvial valleys may also be poorly defined.

The following is a series of steps employed to estimate the discharge at a given exceedance probability for an ungaged site, using Spring Valley Creek near Eagle, Idaho (13207000) as an example (Figure B-15).

Step 1: Locate the drainage basin in Figure B-15 and determine the region in which it is located (in this case, region 2).

Step 2: From Figure B-13 determine the equations to be used from the basin size and compute the mean and standard deviation of logarithms of annual peak discharges. For the example given, drainage area, mean annual precipitation, and altitude are 20.9 square miles, 14 inches, and 3,990 feet, respectively. Mean logarithm is 2.026 and standard deviation of the logarithms is 0.354.

Step 3: The annual peak discharge can be caused by snowmelt or rainstorm runoff because the drainage basin is completely below 6,000 feet and the mean altitude is 3,990 feet. Therefore, sheet 3 of Figure B-17 is used to identify the generalized skew coefficient (G), which, in this case, is 0.

Step 4: For a log-Pearson Type III variable at exceedance probability (P_e):

$$\text{Log } Q_{P_e} = M + K_{P_e} S \tag{3}$$

Here, M = 2.026; S = 0.354. From data table F, at $P_e = 0.02$ and G = 0, K is 2.054; therefore:

$$\text{Log } Q = 2.026 + 2.054\,(0.354) \tag{4}$$

and

$$Q = 566 \text{ ft}^3/\text{s} \tag{5}$$

where

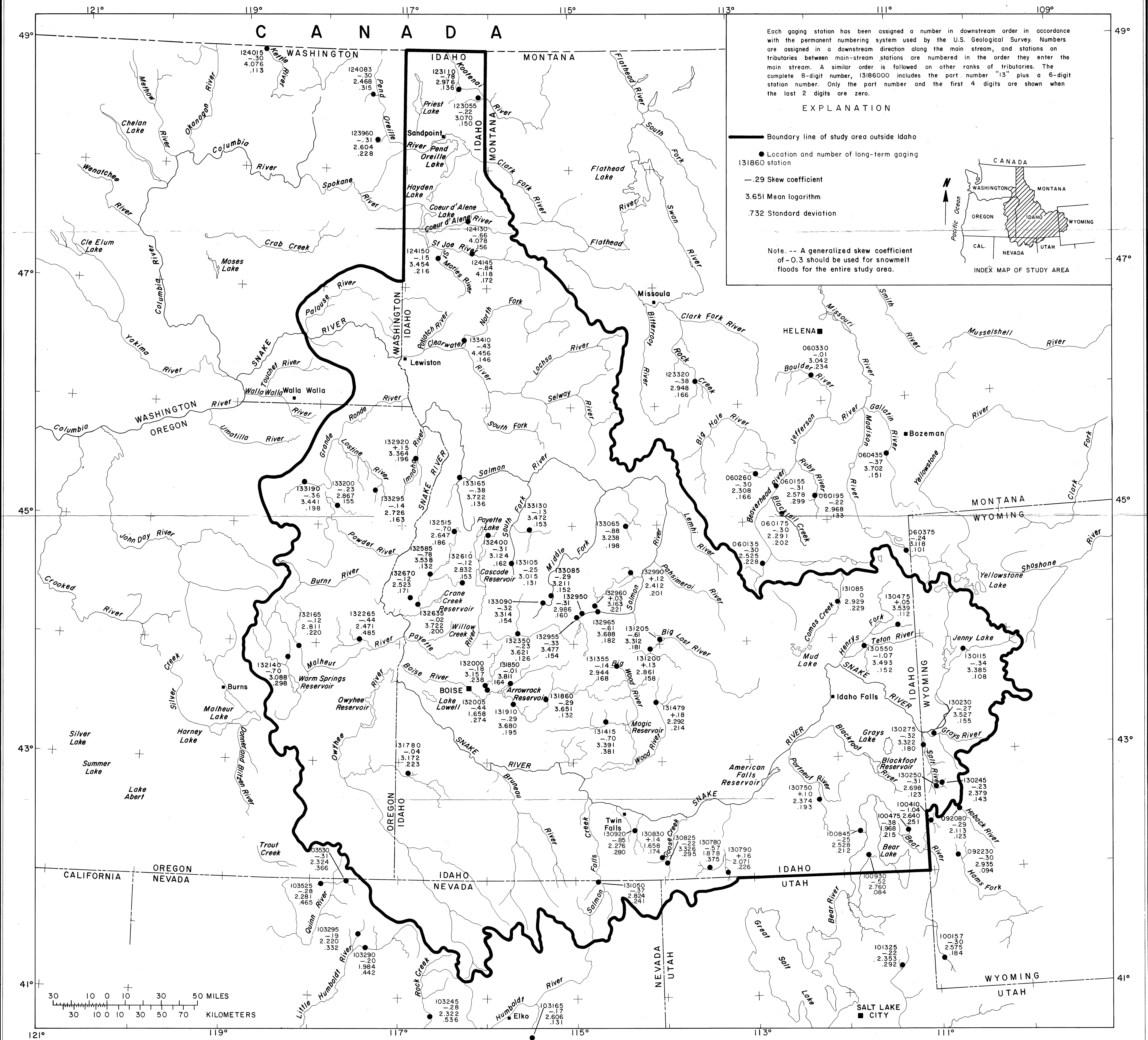
Q	=	discharge
M	=	Mean log of annual maximum discharge.
S	=	Standard Deviation

Step 5: Compare with nearby gaging stations (Figure B-15). In this case, Dry Creek near Eagle, Idaho (13207500), drainage area 59.4 square miles, and Bryans Run near Boise, Idaho (13210300), drainage area 7.94 square miles, have runoffs of 15.3 $(\text{ft}^3/\text{s})/\text{mi}^2$ and 55.4 $(\text{ft}^3/\text{s})/\text{mi}^2$, respectively. The 27.1 $(\text{ft}^3/\text{s})/\text{mi}^2$ runoff from Spring Valley Creek appears to be reasonable from this comparison.

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

PREPARED IN COOPERATION WITH
U.S. ARMY CORPS OF ENGINEERS,
U.S. BUREAU OF RECLAMATION,
U.S. BUREAU OF LAND MANAGEMENT,
AND IDAHO TRANSPORTATION DEPARTMENT

OPEN-FILE REPORT 81-909
PLATE 1



Base from U.S. Geological Survey 1:1,000,000
Columbia River Basin, 1948

GENERALIZED SKEW COEFFICIENT MAP FOR PEAKS CAUSED BY SNOWMELT

UNITED STATES DEPARTMENT OF THE INTERIOR
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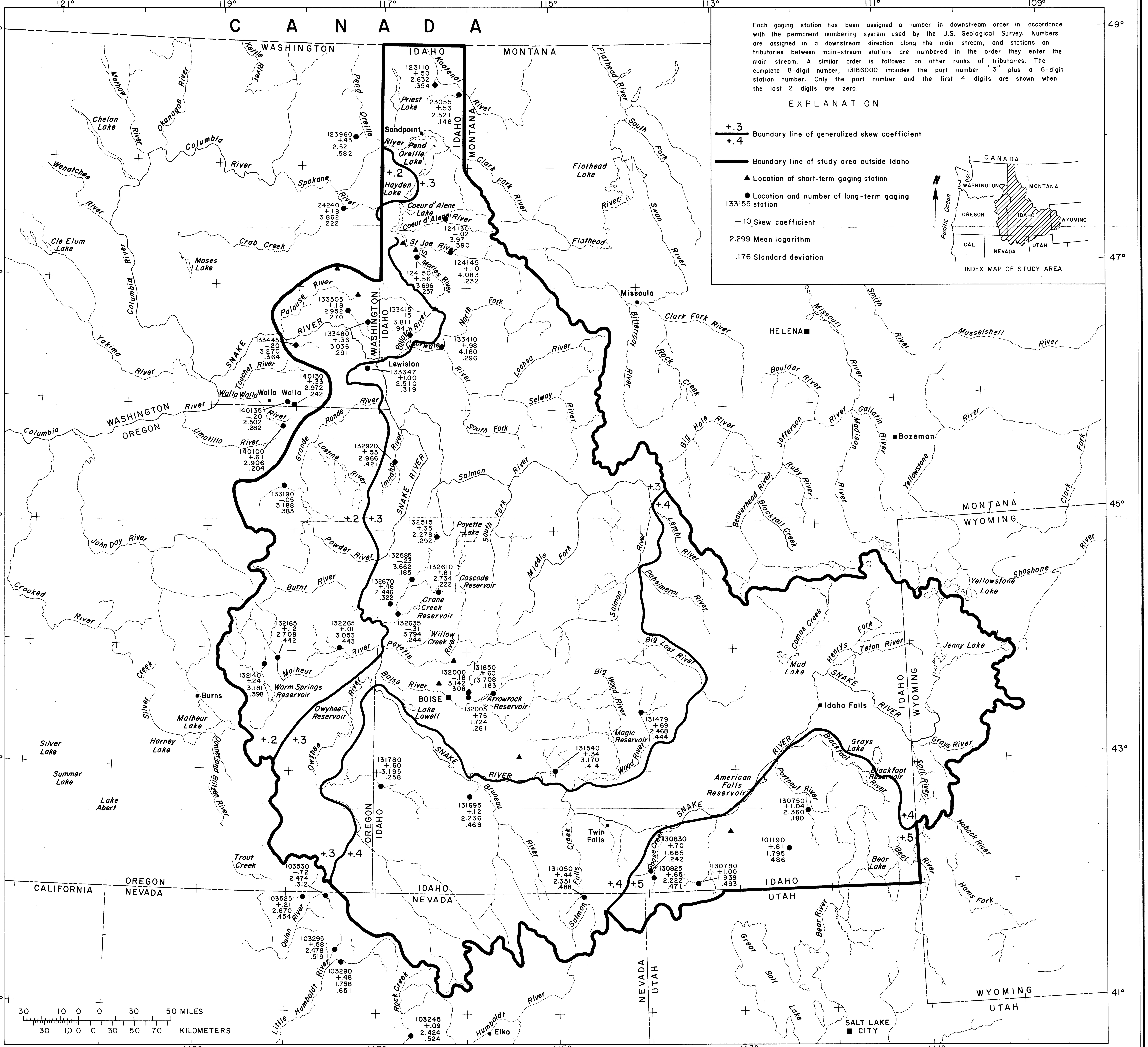
AND IDAHO TRANSPORTATION DEPARTMENT

OPEN-FILE REPORT 81-909
PLATE 2



Base from U.S. Geological Survey 1:1,000,000
Columbia River Basin, 1948

GENERALIZED SKEW COEFFICIENT MAP FOR PEAKS CAUSED BY RAINSTORMS

UNITED STATES DEPARTMENT OF THE INTERIOR
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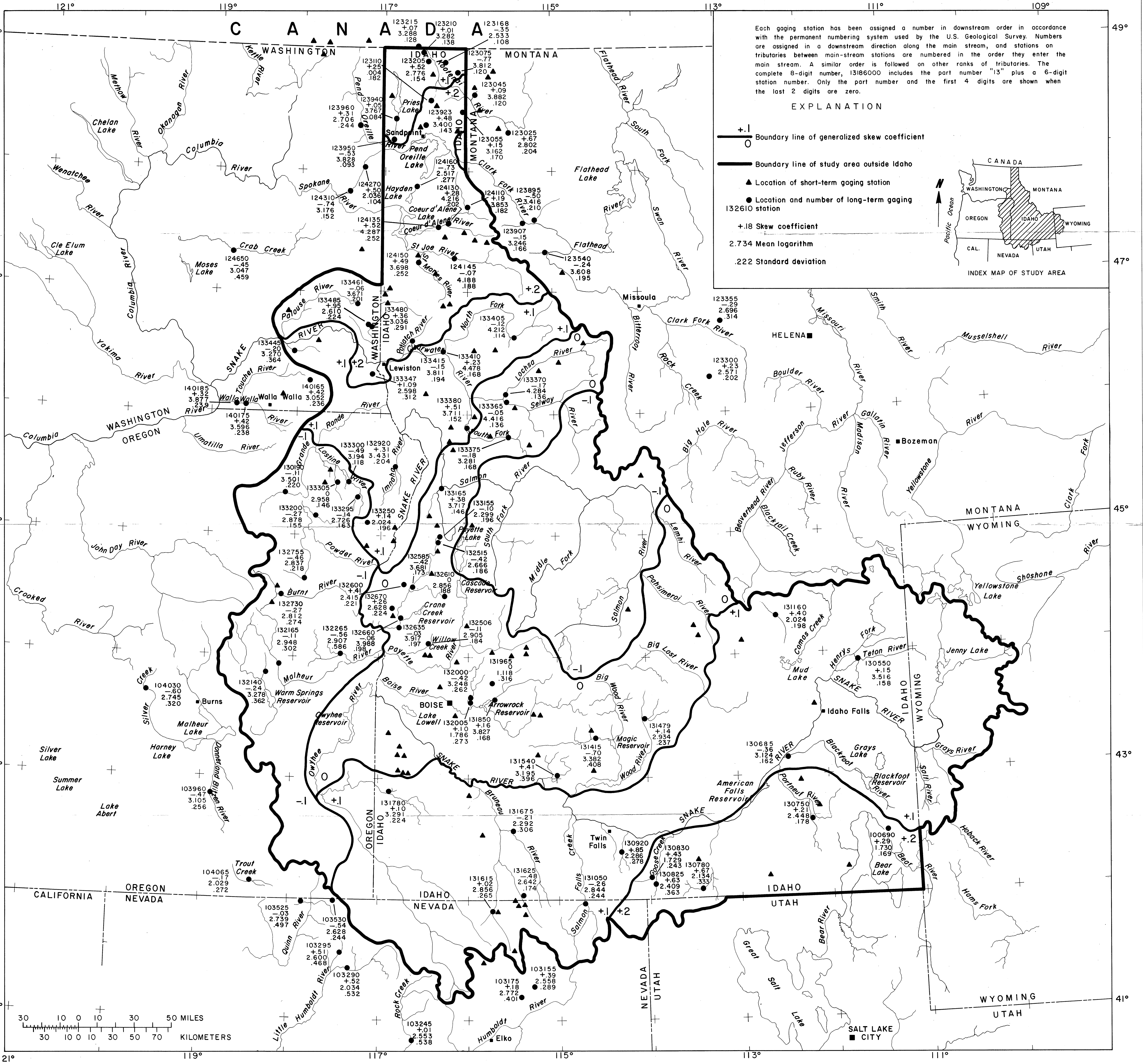
AND IDAHO TRANSPORTATION DEPARTMENT

OPEN-FILE REPORT 81-909
PLATE 3



Base from U.S. Geological Survey 1:1,000,000
Columbia River Basin, 1948

GENERALIZED SKEW COEFFICIENT MAP FOR ANNUAL MAXIMUM PEAKS CAUSED BY EITHER SNOWMELT OR RAINSTORMS

Summary and Conclusions

Generalized skew coefficient maps (sheets 1, 2, and 3 of Figure B-17) were prepared for the study area for (1) snowmelt, (2) rainstorm, and (3) snowmelt or rainstorm floods. Average skew coefficients for gaging stations shown on each of the skew maps are indicative of the differences in skew coefficients resulting from separate analysis of flood types. Skew values determined from the three categories of floods mentioned above averaged -0.31, 0.17, and -0.05, respectively. The values used to compute each of these averages are, however, widely spaced and have standard deviations of 0.27, 0.32, and 0.38, respectively.

Generalized skew maps for peaks caused by rainstorms and annual maximum peaks caused by either snowmelt or rainstorms were made by plotting the station skews and determining a regional pattern. Most of the generalized skew boundary lines coincide with hydrologic unit boundaries (U.S. Geological Survey, 1975). In attempting to develop a method to estimate generalized skew, regression equations using basin characteristics did not adequately define variability of the skew coefficient.

Generalized skew coefficients range from +0.2 to +0.5 for analysis of rainstorm floods, and -0.1 to +0.2 for analysis of annual maximum peaks caused by either snowmelt or rainstorms. Although the skew maps provide considerably different values, some consistency between the findings of this study and the generalized skew coefficient map in Bulletin 17A should be noted. Bulletin 17A applies a generalized skew coefficient of -0.3 to much of Idaho. This coefficient was based on gaging stations having 25 or more years of record. In developing the Bulletin 17A skew map, greater weight was given to long-term record stations. The floods at many of these long-term stations are caused only by snowmelt. Thus, the skew on the Bulletin 17A map would seem to correspond to the generalized skew obtained for snowmelt floods in the present study.

The generalized skew coefficients on sheets 1 and 2 of Figure B-17should be used only where the annual maximum peak is dominated by one type of flood or where separate snowmelt and rainstorm flood arrays are available for analysis. At stations where it is not possible to develop separate flood arrays, the annual maximum peaks and the generalized skew coefficients from sheet 3 of Figure B-17should be used.

Percentage of drainage area below 6,000-foot altitude can be used as a guideline for determining the type of flood. Except for the southwestern corner of the study area, stations having less than 20 percent of drainage area below 6,000 feet should be considered as being dominated by snowmelt floods. Except for southeastern Washington, few gaging stations were observed to be dominated by rainstorm floods. The generalized skew coefficient map for rainstorm floods (sheet 2 of Figure B-17) should be used when a combined frequency curve for both types of floods is being prepared or where the mean altitude of the basin is below 3,000 feet.

B.50 – OPEN CHANNELS AND BRIDGES

B.50.01 Field Data Cross Sections for Backwater Computations. An example of this procedure is illustrated in an application to the Red Fox River, Colorado. Figure B-18 is a plan view showing the river, contours on the flood plain, and the location and alignment of cross sections. The stream flows from west to east. Cross sections are plotted in Figure B-19. The cross sections start at some point downstream and progress upstream. They are measured from left to right when looking downstream. The data will be more adaptable if some reference distance such as 500 is assigned to the low point of the channel.

The location and alignment of cross sections are very important because they describe the geometric model that is the basis for the entire series of computations. Contour lines are used in orienting sections perpendicular to the expected current directions, and the results often require angle points to model both channel and overbank flow. In this example, no cross sections intersect. In cases where cross sections do tend to cross, the cross section alignments should run parallel to each other to high ground and some small, positive value should be assigned for each reach length. Zero reach lengths should be avoided so that dividing by zero will not occur in subsequent computations.

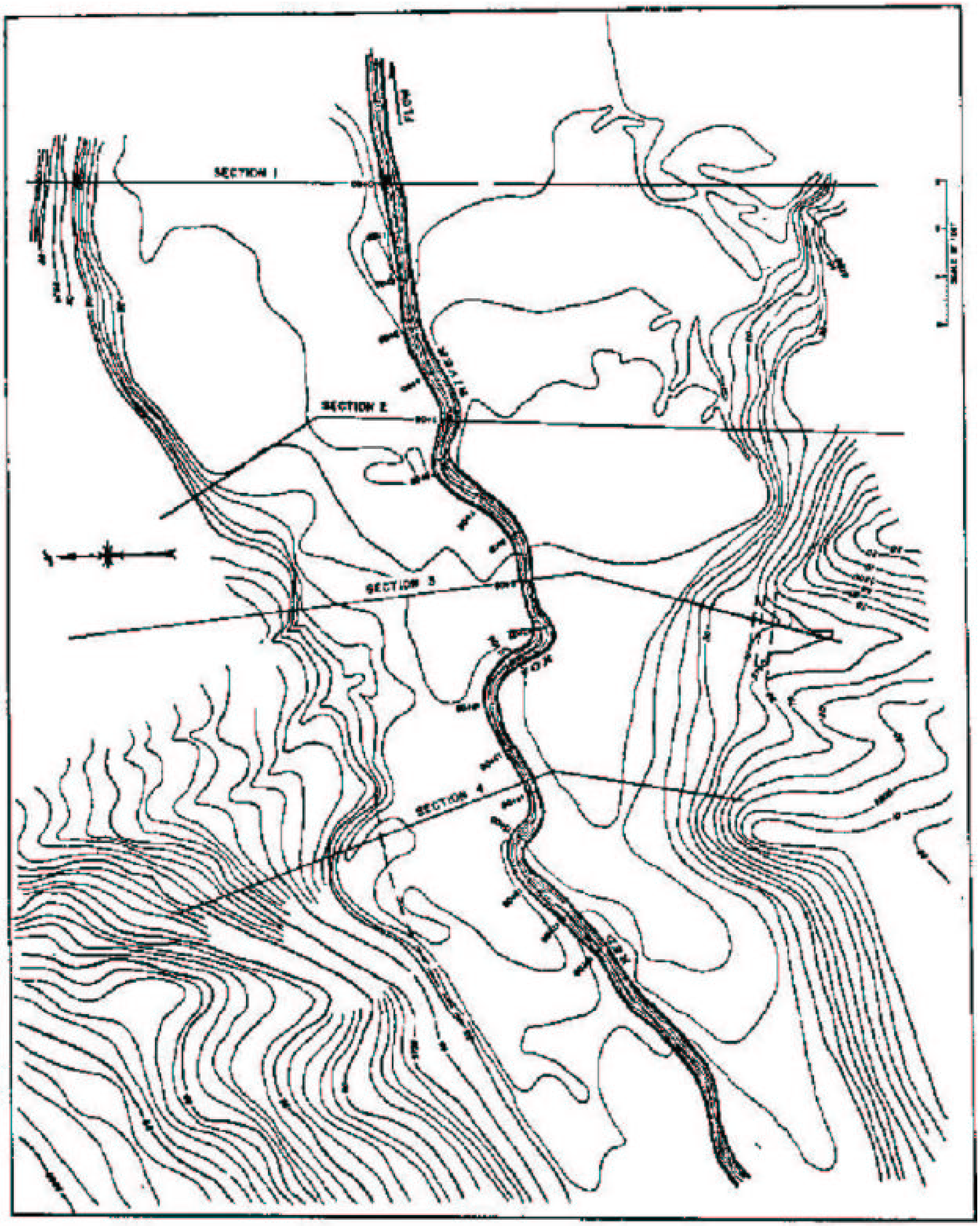
Hydraulic roughness values or n values should be obtained from the field. Each cross section represents a reach of the river that extends half way to the next cross section in each direction. This should be kept in mind when determining the n values.

Examples of cross sections taken to measure a flood by the U.S. Geological Survey are shown in Figure D-21. The roughness values should be shown on each cross section, as they are helpful in locating where a cross section should be subdivided to determine distributed properties. Mannings n values (Chow, Open Channel Hydraulics 1959) are shown in Table B-5.

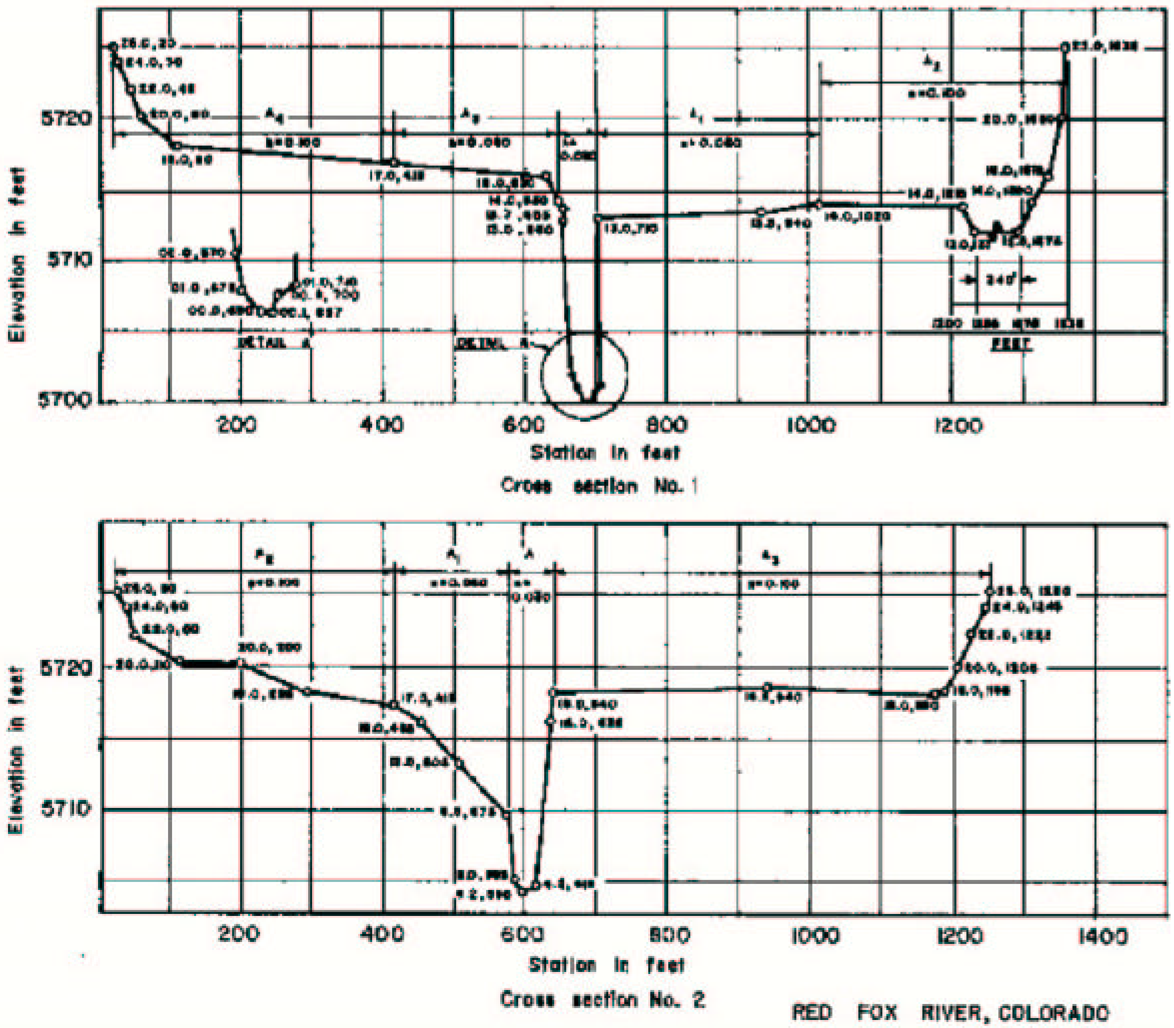
B.50.02 Hydrologic Regional Calculations. U.S. Geological Survey hydrologic regional equations can be computed using the National Flood Frequency (NFF) option under the HYDRAIN, HYDRO computer program

B.50.03 Hydraulic Backwater Calculations. Hydraulic backwater calculations for bridges over natural streams should be done using the Army Corps of Engineers, River Analysis System (HEC-RAS) computer program. Selected examples of riprap typical sections are given in Figure B-22, sheets 1 through 5.

Figure B-18



Plan view of the Red Fox River, Colorado



Cross sections of Red Fox River, Colorado

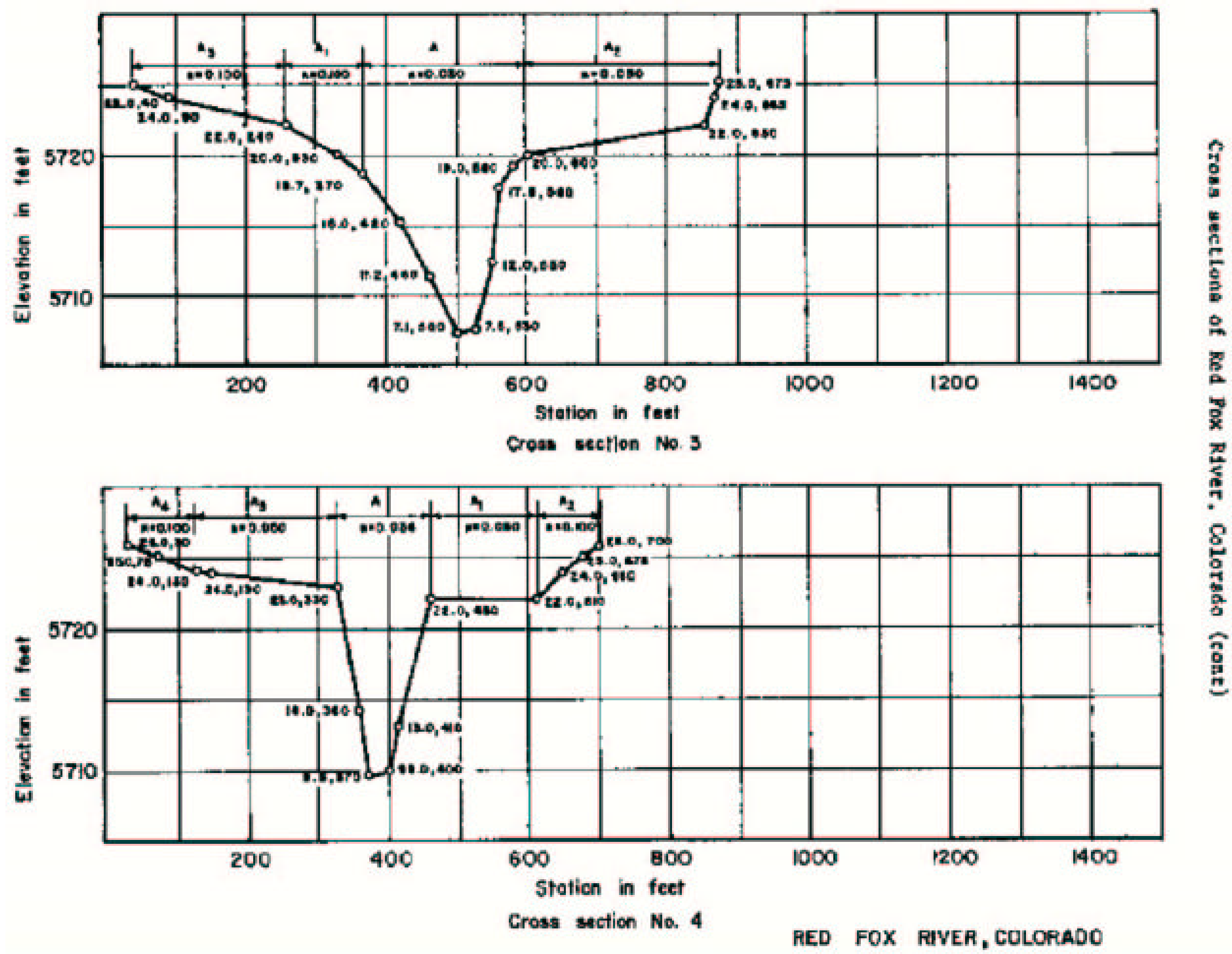

Elevation in feet
5720
5710
200
400
600
800
1000
1200
1400
Station in feet
Cross section No. 3
Elevation in feet
5720
5710
Station in feet
Cross section No. 4
RED FOX RIVER, COLORADO
Cross sections of Red Fox River, Colorado (cont)

Figure B-20

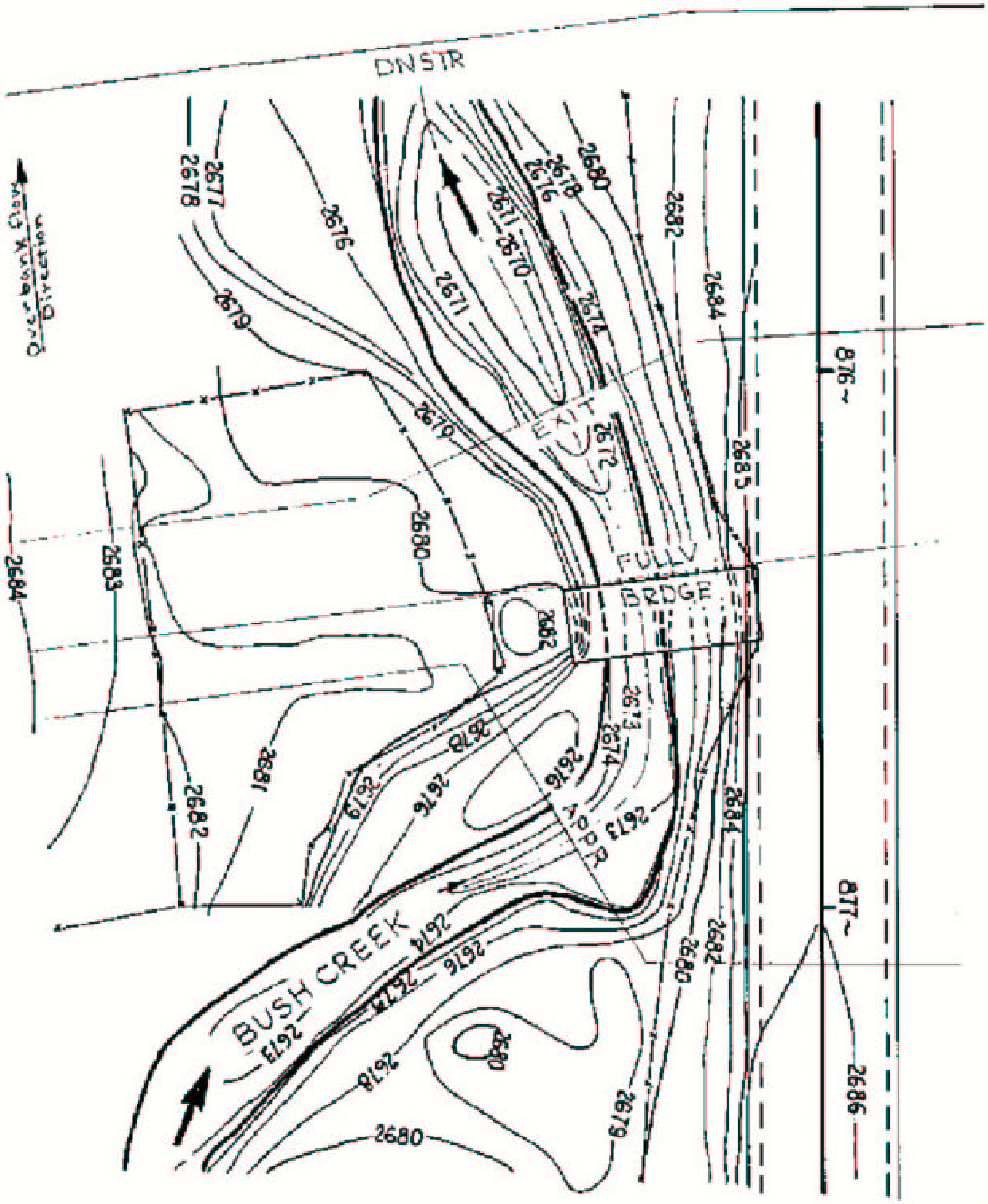

DNSTR
EXIT
FULL
BRDGE
APPR
BUSH CREEK
Overbank Flow Direction
2678
2677
2676
2679
2671
2670
2680
2682
2684
2685
2683
2673
2674
2686

Figure B-21

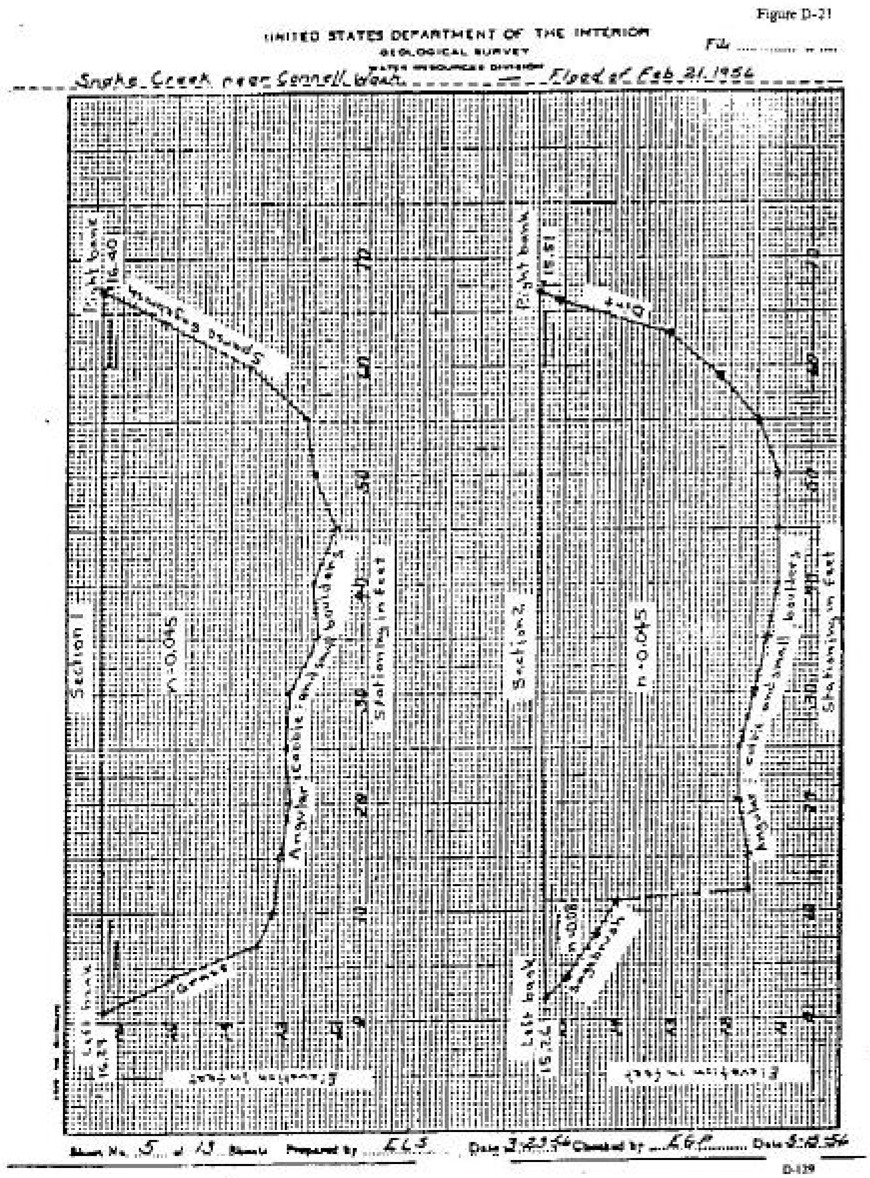


Figure D-21
UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
WATER RESOURCES DIVISION
Snake Creek near Connell, Wash.
Flood of Feb. 21, 1956
Section 1
n=0.045
Section 2
n=0.045
Stationing in feet
Elevation, in feet
Sheet No. 5 of 13 Sheets Prepared by ELS Date 3-23-56 Checked by EGP Date 5-10-56
D-129

VALUES OF THE ROUGHNESS COEFFICIENT n

Type of Channel and Description	Minimum	Normal	Maximum
A. Lined or Built-up Channels			
A-1. Metal			
a. Smooth steel surface			
1. Unpainted	0.011	0.012	0.014
2. Painted	0.012	0.013	0.017
b. Corrugated	0.021	0.025	0.030
A-2. Nonmetal			
a. Cement			
1. Neat, surface	0.010	0.011	0.013
2. Mortar	0.011	0.013	0.015
b. Wood			
1. Planed, untreated	0.010	0.012	0.014
2. Planed, creosoted	0.011	0.012	0.015
3. Unplaned	0.011	0.013	0.015
4. Plank with battens	0.012	0.015	0.018
5. Lined with roofing paper	0.010	0.014	0.017
c. Concrete			
1. Trowel finish	0.011	0.013	0.015
2. Float finish	0.013	0.015	0.016
3. Finished, with gravel on bottom	0.015	0.017	0.020
4. Unfinished	0.014	0.017	0.020
5. Gunite, good section	0.016	0.019	0.023
6. Gunite, wavy section	0.018	0.022	0.025
7. On good excavated rock	0.017	0.020	
8. On irregular excavated rock	0.022	0.027	

VALUES OF THE ROUGHNESS COEFFICIENT n

Type of Channel and Description	Minimum	Normal	Maximum
A. Lined or Built-up Channels (continued)			
A-2. Nonmetal (continued)			
d. Concrete bottom float finished with sides of:			
1. Dressed stone in mortar	0.015	0.017	0.020
2. Random stone in mortar	0.017	0.020	0.024
3. Cement rubble masonry, plastered	0.016	0.020	0.024
4. Cement rubble masonry	0.020	0.025	0.030
5. Dry rubble or riprap	0.020	0.030	0.035
e. Gravel bottom with sides of:			
1. Formed concrete	0.017	0.020	0.025
2. Random stone in mortar	0.020	0.023	0.026
3. Dry rubble or riprap	0.023	0.033	0.036
f. Brick			
1. Glazed	0.011	0.013	0.015
2. In cement mortar	0.012	0.015	0.018
g. Masonry			
1. Cemented rubble	0.017	0.025	0.030
2. Dry rubble	0.023	0.032	0.035
h. Dressed ashlar	0.013	0.015	0.017
i. Asphalt			
1. Smooth	0.013	0.013	
2. Rough	0.016	0.016	
j. Vegetal lining	0.030	....	0.500
B. Excavated or Dredged			
a. Earth, straight and uniform			
1. Clean, recently completed	0.016	0.018	0.020
2. Clean, after weathering	0.018	0.022	0.025
3. Gravel, uniform section, clean	0.022	0.025	0.030
4. With short grass, few weeds	0.022	0.027	0.033

VALUES OF THE ROUGHNESS COEFFICIENT n

Type of Channel and Description	Minimum	Normal	Maximum
B. Excavated or Dredged (continued)			
b. Earth, winding and sluggish			
1. No vegetation	0.023	0.025	0.030
2. Grass, some weeds	0.025	0.030	0.033
3. Dense weeds or aquatic plants in deep channels	0.030	0.035	0.040
4. Earth bottom and rubble sides	0.028	0.030	0.035
5. Stony bottom and weedy banks	0.025	0.035	0.040
6. Cobble bottom and clean sides	0.030	0.040	0.050
c. Dragline-excavated or dredged			
1. No vegetation	0.025	0.028	0.033
2. Light brush on banks	0.035	0.050	0.060
d. Rock cuts			
1. Smooth and uniform	0.025	0.035	0.040
2. Jagged and irregular	0.035	0.040	0.050
e. Channel not maintained, weeds & brush uncut			
1. Dense weeds, high as flow depth	0.050	0.080	0.120
2. Clean bottom, brush on sides	0.040	0.050	0.080
3. Same, highest stage of flow	0.045	0.070	0.110
4. Dense brush, high stage	0.080	0.100	0.140
C. Natural Streams			
C-1. Minor streams (top width at flood stage less than 100 ft.)			
a. Streams on plain			
1. Clean, straight, full stage, no rifts or deep pools	0.025	0.030	0.033
2. Same as above, but more stones and weeds	0.030	0.035	0.040
3. Clean, winding, some pools/shoals	0.033	0.040	0.045
4. Same as above, but some weeds and stones	0.035	0.045	0.050
5. Same as above, lower stages, more ineffective slopes and sections	0.040	0.048	0.055
6. Same as 4, but more stones	0.045	0.050	0.060

VALUES OF THE ROUGHNESS COEFFICIENT n

Type of Channel and Description	Minimum	Normal	Maximum
C. Natural Stream (continued)s			
C-1. Minor streams (top width at flood stage <100 ft.) (continued)			
a. Streams on plain (continued)			
7. Sluggish reaches, weedy, deep pools	0.050	0.070	0.080
8. Very weedy reaches, deep pools, or floodways w/heavy stand of timber and underbrush	0.075	0.100	0.150
b. Mountain streams, no vegetation in channel, banks usually steep, trees & brush along banks submerged at high stages			
1. Bottom—gravels/cobbles/boulders	0.030	0.040	0.050
2. Bottom—cobbles w/large boulders	0.040	0.050	0.070
C-2. Flood plains			
a. Pasture, no brush			
1. Short grass	0.025	0.030	0.035
2. High grass	0.030	0.035	0.050
b. Cultivated areas			
1. No crop	0.020	0.030	0.040
2. Mature row crops	0.025	0.035	0.045
3. Mature field crops	0.030	0.040	0.050
c. Brush			
1. Scattered brush, heavy weeds	0.035	0.050	0.070
2. Light brush and trees in winter	0.035	0.050	0.060
3. Light brush and trees in summer	0.040	0.060	0.080
4. Medium to dense brush, winter	0.045	0.070	0.110
5. Medium to dense brush, summer	0.070	0.100	0.160
d. Trees			
1. Dense willows, summer, straight	0.110	0.150	0.200
2. Cleared land w/tree stumps, no sprouts	0.030	0.040	0.050
3. Same as above, but w/heavy growth of sprouts	0.050	0.060	0.080

VALUES OF THE ROUGHNESS COEFFICIENT n

Type of Channel and Description	Minimum	Normal	Maximum
C. Natural Stream (continued)s			
C-2. Flood plains (continued)			
d. Trees (continued)			
4. Heavy stand of timber, a few down trees, little undergrowth, flood stage below branches	0.080	0.100	0.120
5. Same as above, but with flood stage reaching branches	0.100	0.120	0.160
C-3. Major streams (top width at flood stage >100 ft.), the n value is less than that for minor streams of similar description, because banks offer less effective resistance			
a. Regular section w/no boulders or brush	0.020	…….	0.060
b. Irregular and rough section	0.035	…….	0.100

B.60 – RIPRAP DETAILS

Figures B-22 to B-28 are to be used to determine riprap.

Procedure for Determining if Filter Fabric is Required **Figure B-22**

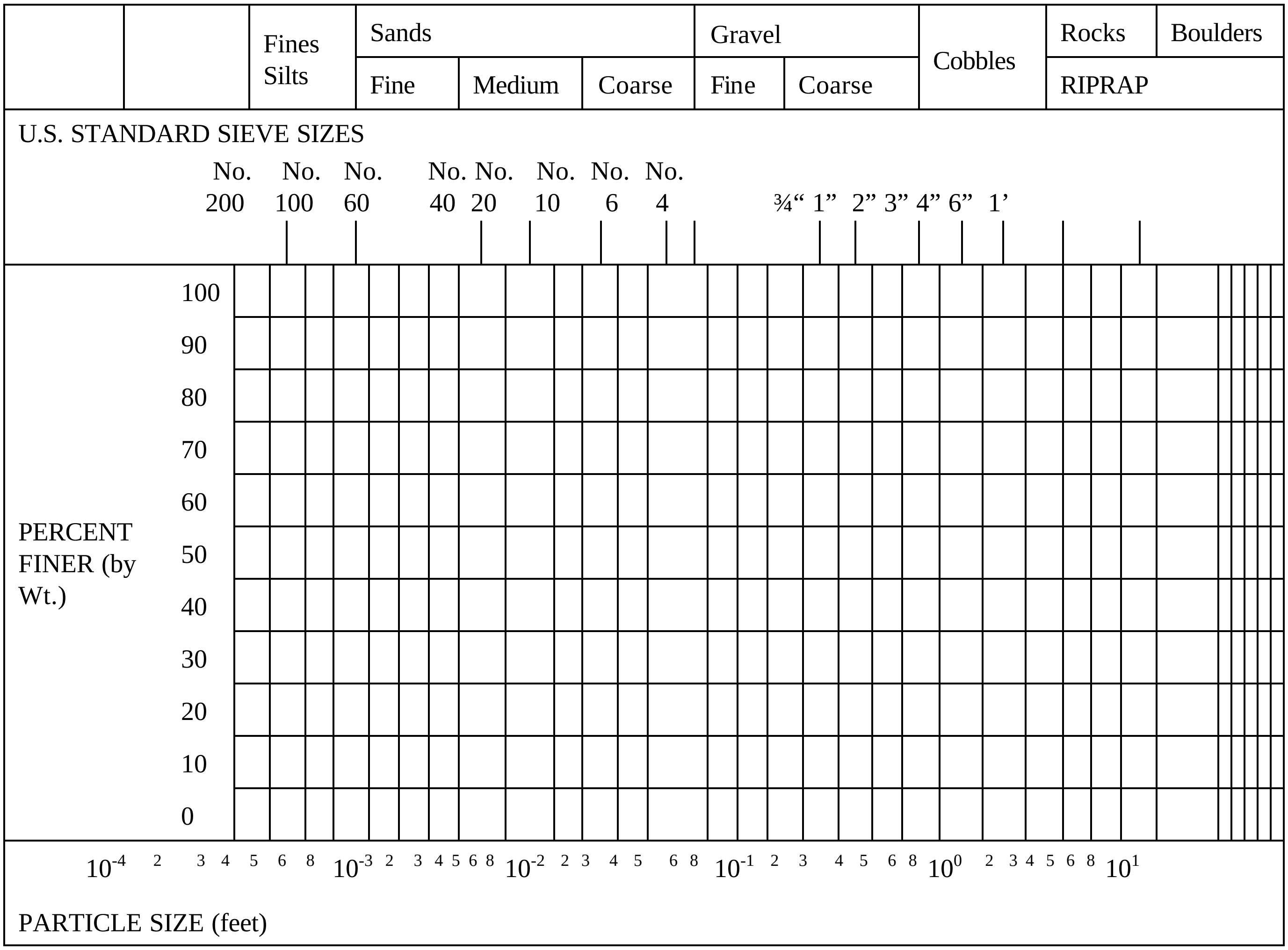
1) Obtain sieve analysis of parent (base) material.
2) Plot Gradations on the following Gradation Curve Chart. (Figure B-23)
3) From the Gradation Curve Chart, determine the D_{15}, D_{50}, and D_{85} sizes.
4) Determine the D_{15}, D_{50}, and D_{85} riprap size as outlined in HEC-11 or HEC-18.
5) Determine if filter fabric is required from:

$$\frac{D_{15}\ \text{Riprap}}{D_{85}\ \text{Base}} < 5 < \frac{D_{15}\ \text{Riprap}}{D_{15}\ \text{Base}} < 40$$

$$\frac{D_{50}\ \text{Riprap}}{D_{50}\ \text{Base}} < 40$$

6) If the above *criteria is met*, no filter fabric is required.If the above *criteria is not met*, a filter fabric will be required.
7) Select approved filter fabric.

Gradaition Curve Chart Figure B-23



TYPICAL SECTION
NORMAL TO CHANNEL

Figure B-24

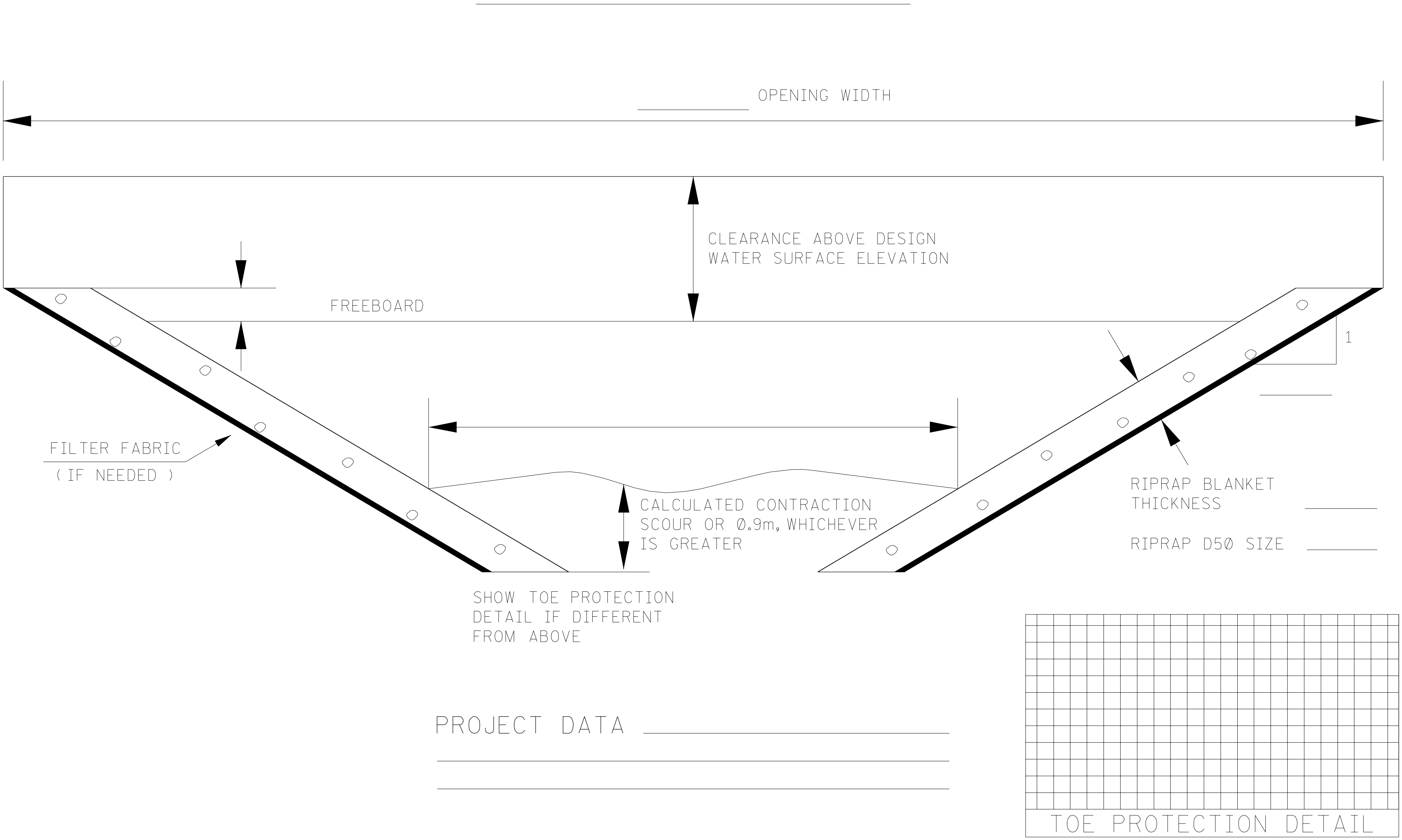


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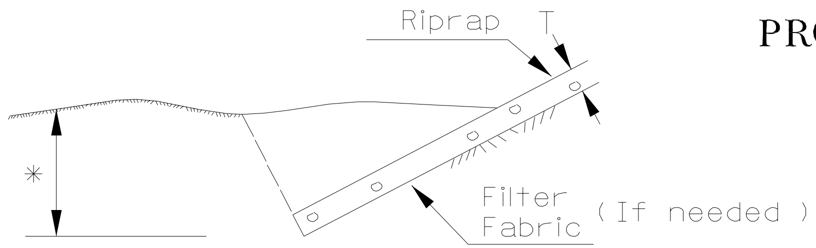
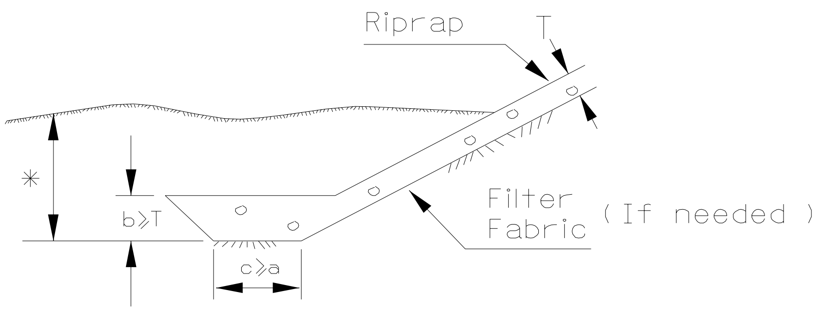
Figure B-25

ACCEPTABLE TOE PROTECTION

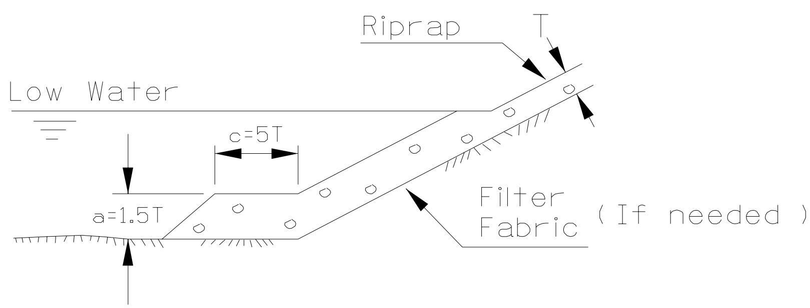


METHOD 1: This is most suited to areas where the toe is dry during construction

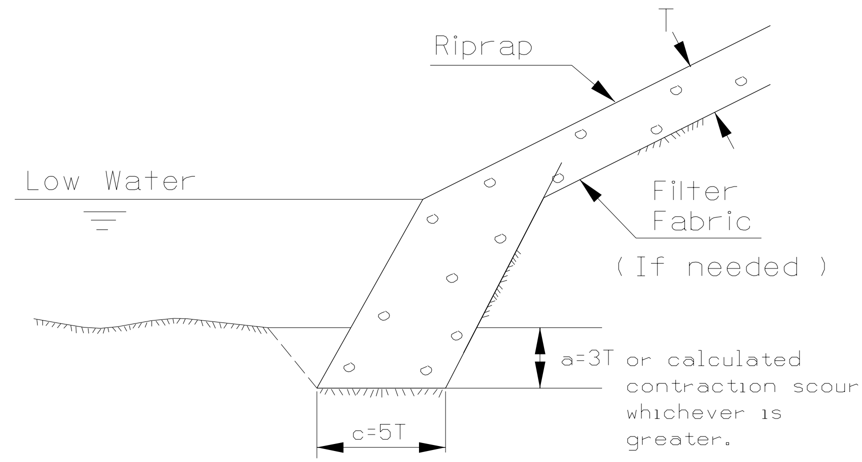
* calculated contraction scour depth or 0.9m whichever is greater



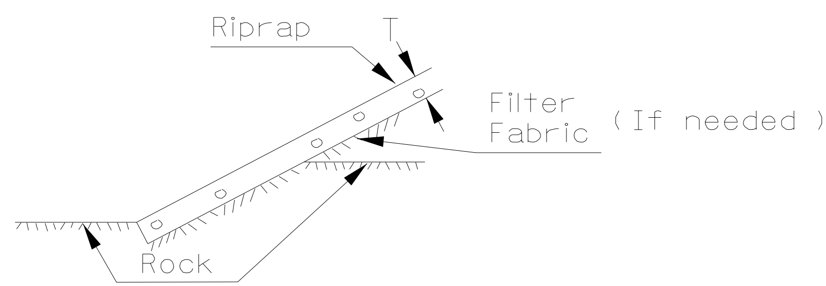
METHOD 2: Used when the streambed is very wet or groundwater present makes using Method 1 impractical.



METHOD 3: Often used when toe is underwater during construction. Both methods 2 and 3 utilize the idea that undermining will cause rock at the toe blanket to settle into the eroded area providing protection during scouring.



METHOD 4: Used underwater in areas with extremely bad streambed erosion conditions which make Method 3 infeasible. This method may also be preferred where Method 3 would destroy fish spawning beds.



METHOD 5: When the Streambed is non-erodible, no special provisions for toe protection are needed other than insuring that the riprap is well keyed into the rock.

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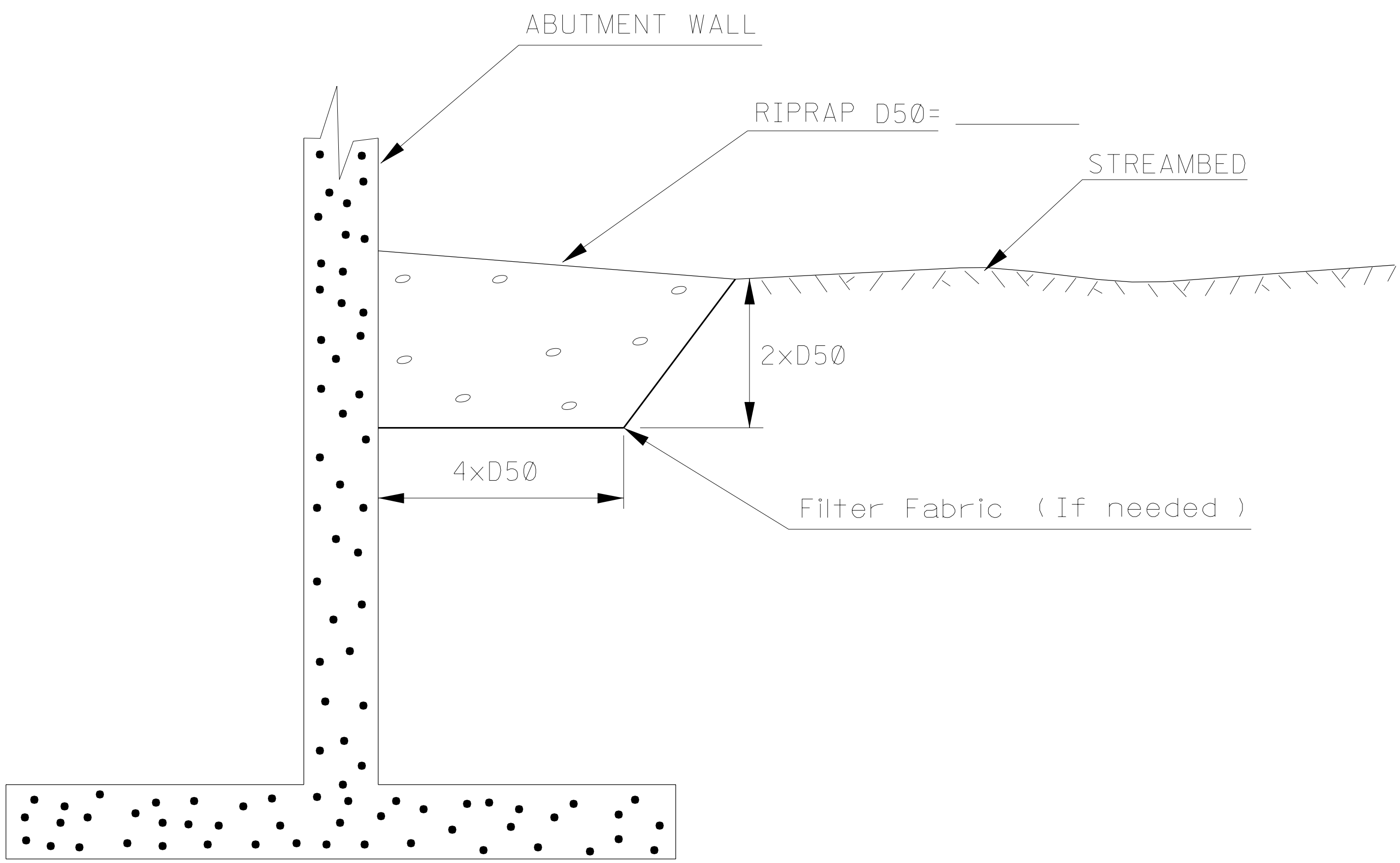
Figure B–26



RIPRAP DETAIL
FOR
VERTICAL ABUTMENT

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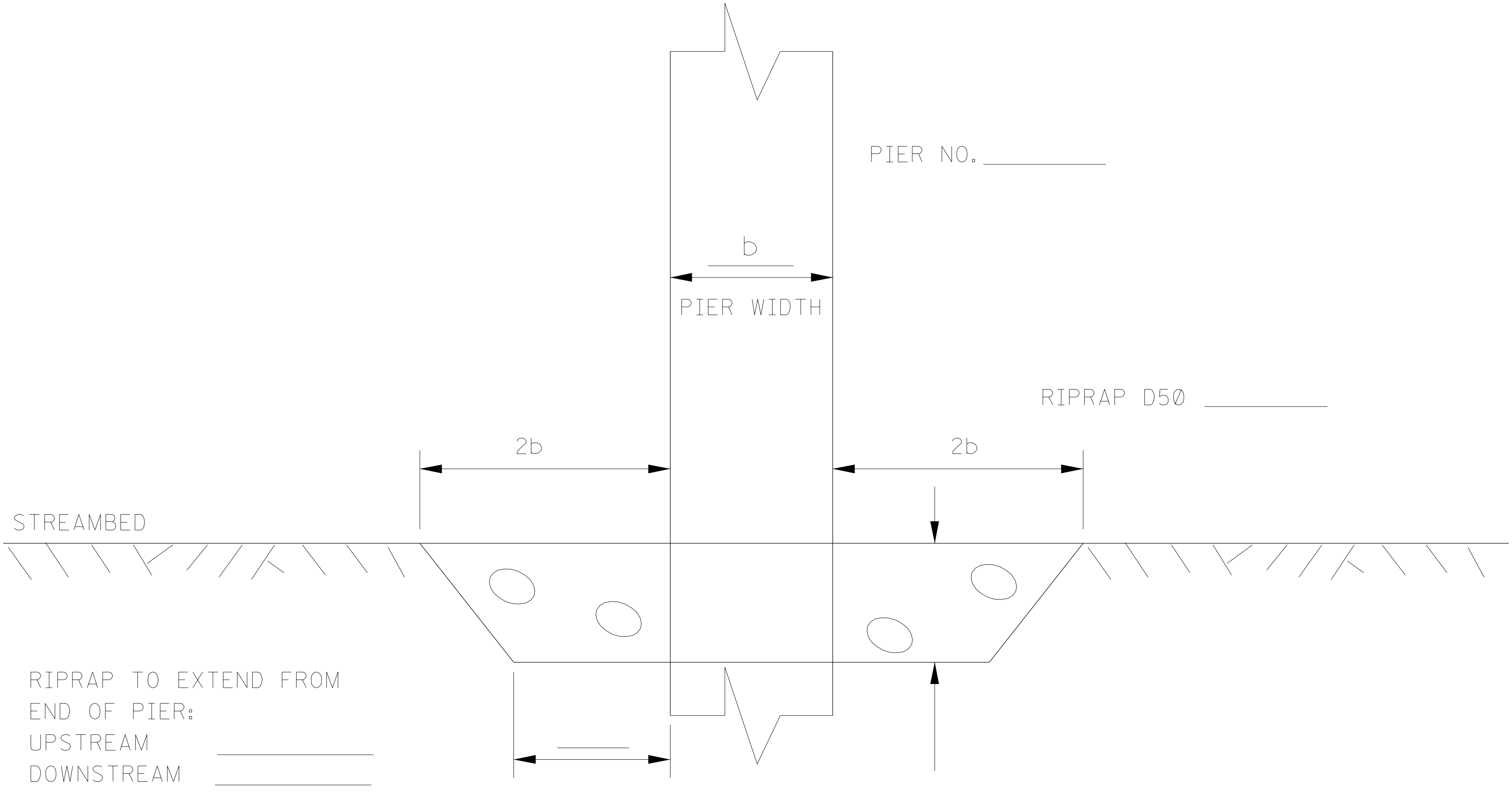
Figure B-27

PIER PROTECTION



PROJECT DATA ______________________________

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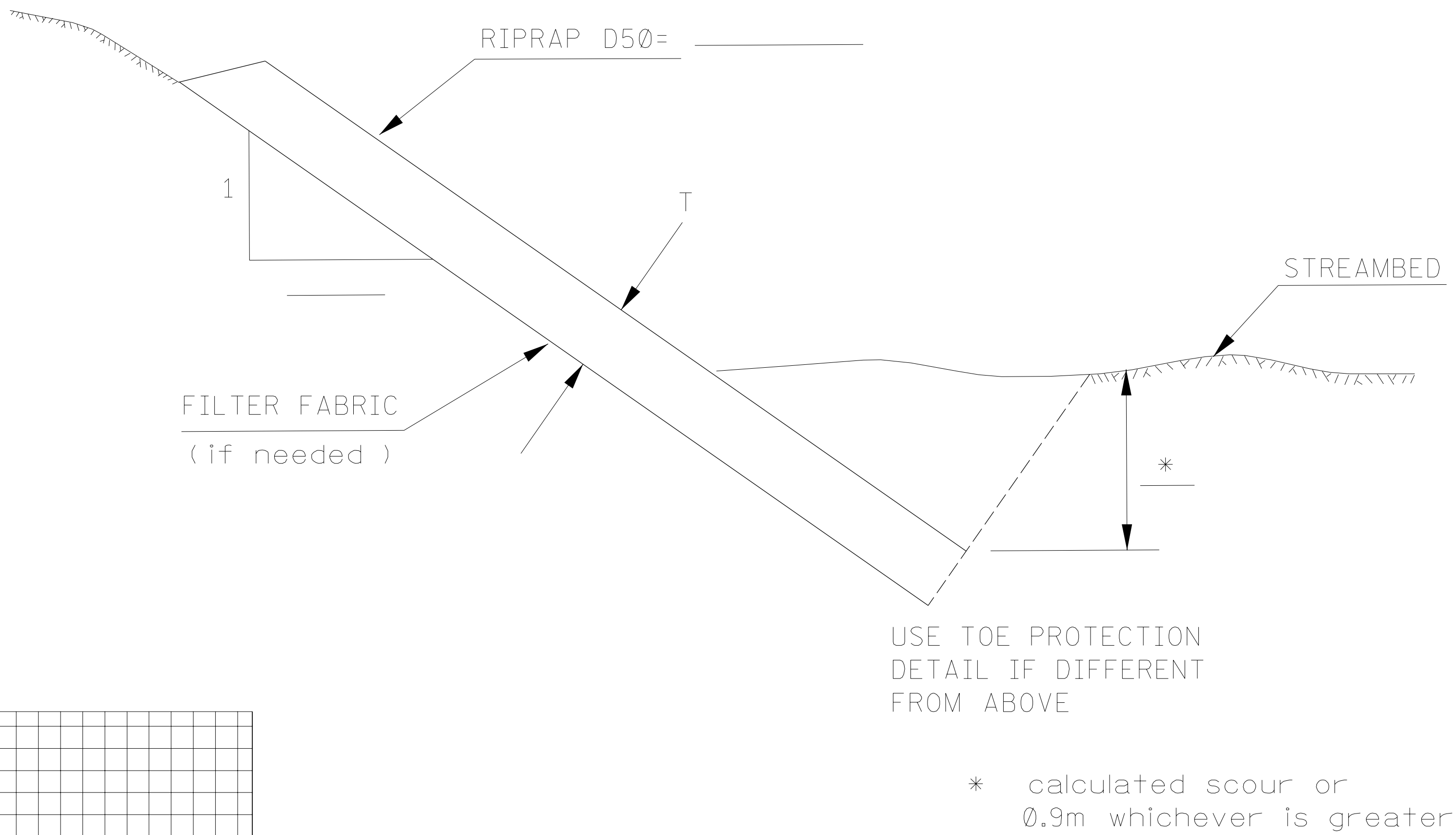
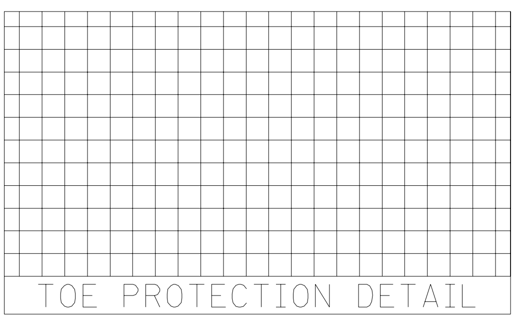
Figure B–28





RIPRAP DETAIL
FOR
BANK PROTECTION

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